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Project 85-493

INTERIM REPORT

LONG TERM MONITORING AND DATA BASE DEVELOPMENT FOR APPLIED ANAEROBIC DIGESTION TECHNOLOGY IN CANADA

Prepared for:

BIOENERGY DEVELOPMENT PROGRAM
RENEWABLE ENERGY DIVISION
COAL AND ALTERNATIVE ENERGY BRANCH
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PREFACE

This interim report is intended to describe the development of a computer conferencing data base containing design information from anaerobic digestion systems in Canada, describe a long term monitoring and data collection program for anaerobic digestion systems operating in Canada and to describe the presentation of the project concepts at the Fourth International Symposium on Anaerobic Digestion in Guangzhou, China in November, 1985.

This project is designed to summarize engineering design information and operational data from anaerobic digestion facilities built in Canada on a computerized data base and make it accessible across Canada. This report was prepared for government personnel, engineering firms, industries and individuals attempting to design or evaluate anaerobic digestion technology in Canada.

The anaerobic digester design information contained in this report and on the data base was collected through telephone conversations and meetings with appropriate contact persons involved with each anaerobic digester facility and by reviewing information contained in project reports and publications. The information contained in the data base was returned to each contact person for verification prior to publication.

ABSTRACT

The overall objectives of this project are to develop a computer data base to contain engineering process design information from anaerobic digestion facilities operating on agricultural and industrial wastes built in Canada, to develop a digester process monitoring and data collection program to update the data base with operational data and to develop a computer confering system for information exchange between operators, designers and government personnel.

An inventory of anaerobic digestion systems in Canada was established by contacting federal and provincial government officials, universities, engineering firms and individuals involved with anaerobic digestion technology. An extensive literature review of project reports, presentations, journals and other publications was conducted. There are approximately 15 full-scale or large pilot-scale digesters constructed in Canada and 2 systems are at the design or construction stage.

The engineering design and operational data collected is stored on the Cosy Computer Conferencing System at the University of Guelph and is accessible across Canada through DATAPAC, TYMNET and TELENET. This data base is the only comprehensive summary of Canadian anaerobic digestion facilities.

The project concept was presented at the Fourth International Symposium on Anaerobic Digestion in Guangzhou, China in November, 1985 and numerous inquiries for additional information and access to the data base have been received.

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EXECUTIVE SUMMARY

Anaerobic digestion technology, for agricultural and industrial applications has been receiving increased interest in recent years. Rising energy and feed costs and more stringent environmental regulations have prompted this increased interest. The engineering design and operational conditions at anaerobic digestion facilities in Canada are not readily available or are published in a number of formats making comparisons between facilities difficult. The objectives of the project are to develop a computer data base to contain engineering design information from anaerobic digestion facilities in Canada, to develop a digester monitoring program to update the data base with current operational data and to develop a conferencing system for information exchange.

Federal and provincial government officials, universities, engineering firms and individuals involved in anaerobic digestion technology were contacted in order to establish an inventory of anaerobic digestion systems in Canada. An extensive literature review was also conducted. The information was collected in the form of a questionnaire, compiled into a standard format and entered into ASCII data files on an IBM-PC. The information was edited and then uploaded onto the Cosy Computer Conferencing System at the University of Guelph, Guelph, Ontario. The Canadian Applied Anaerobic Digestion Technology Data Base is accessible across Canada through DATAPAC, TYMNET and TELENET.

The long term digester monitoring program began in January 1986 and was developed to obtain current operational data and anaerobic digestion plant operator comments to update the data base.

The data base contains information from fifteen full-scale and large pilot-scale anaerobic digesters and one that is under construction. Of these, eight digesters are in full operation and are being monitored and another five are due to start-up in the next few months.

The project concept was presented at the Fourth International Symposium on Anaerobic Digestion in Guangzhou, China in November 1985. Posters illustrating representative anaerobic digestion facilities operating on agricultural and industrial wastes in Canada were prepared and presented.

The anaerobic digestion process has been applied effectively to a variety of agricultural and industrial wastes. Engineering design and current operational data from Canadian anaerobic digestion facilities is now available in a standard format on the CoSy Computer Conferencing System at the University of Guelph and is accessible across Canada to government personnel, engineering firms, industries and individuals attempting to design or evaluate this technology.

SOMMAIRE

Les techniques de digestion anaérobie dans les applications agricoles et industrielles ont suscité un intérêt accru au cours des dernières années. L'augmentation des coûts de l'énergie et des produits de base ainsi que la réglementation plus rigide du secteur environnemental ont provoqué cet accroissement d'intérêt. Les plans techniques et les conditions d'exploitation des installations canadiennes de digestion anaérobie ne sont pas faciles à obtenir ou sont publiés sous des formes diverses qui en rendent les comparaisons difficiles. Le projet vise à mettre au point une base de données informatisée renfermant des informations de conception technique sur les installations de digestion anaérobie au Canada, à établir un programme de contrôle des digesteurs permettant de mettre à jour la base de données au moyen des renseignements d'exploitation courants et à monter un système de conférence favorisant les échanges d'informations.

Afin de dresser l'inventaire des systèmes de digestion anaérobie au Canada, nous avons communiqué avec des fonctionnaires des gouvernements fédéral et provinciaux, des universités, des firmes d'ingénierie et des particuliers oeuvrant dans le domaine des techniques de digestion anaérobie. Nous avons également passé en revue un grand nombre de publications spécialisées. Nous avons recueilli les renseignements au moyen d'un questionnaire, les avons compilés sous une forme normalisée et les avons introduits dans des fichiers de données ASCII dans un IBM-PC. Les renseignements ont été révisés puis téléchargés dans le Cosy Computer Conferencing System de l'Université de Guelph, à Guelph (Ontario). La base de données canadienne sur les techniques appliquées de digestion anaérobie est accessible d'un bout à l'autre du Canada par le biais de DATAPAC, de TYMNET et de TELENET.

Le programme à long terme de contrôle des digesteurs a été établi en janvier 1986 afin de mettre à jour la base de données qui repose sur des renseignements d'exploitation courants et des remarques des opérateurs d'installations de digestion anaérobie.

La base de données contient des renseignements sur quinze digesteurs anaérobie, dont certains sont en vraie grandeur alors que d'autres sont de bonne taille, mais à l'échelle pilote. Elle contient également des informations sur un seizième digesteur en cours de construction. Huit de ces digesteurs sont pleinement utilisés et font déjà l'objet d'un contrôle, et cinq autres seront exploités d'ici quelques mois.

Le concept du projet a été présenté lors du Quatrième symposium international sur la digestion anaérobie, qui s'est tenu à Guangzhou, en Chine, en novembre °985. ´ cette occasion, on avait présenté des affiches illustrant des installations représentatives de systèmes de digestion anaérobie, au Canada, alimentés au moyen de déchets agricoles et industriels.

Le processus de digestion anaérobie a été appliqué efficacement à une variété de déchets agricoles. Les plans techniques et les données d'exploitation courantes des installations de digestion anaérobie sont maintenant disponibles d'un bout à l'autre du Canada, sous une forme normalisée, sur le Cosy Computer Conferencing System de l'Université de Guelph. Les fonctionnaires, les firmes d'ingénierie, les industries et les particuliers qui travaillent à l'élaboration ou à l'évaluation des techniques de digestion anaérobie y ont accès.

1.0 INTRODUCTION AND BACKGROUND

Anaerobic digestion technology has been applied to the treatment of municipal wastes for many years. Recently, because of the interest in renewable energy production and energy conservation, this technology is being applied to a number of agricultural and industrial wastes. The application of anaerobic digestion to agricultural and industrial wastes is in its infancy and the availability of adequate engineering design information is extremely limited. Many of the plants designed to date are currently operating at conditions quite different than the original designs. In Canada, there are 15 full-scale and large pilot-scale anaerobic digestion systems, installed and 2 that are at the design or construction stage, treating a variety of agricultural and industrial wastes. The engineering design sizing and the actual operational conditions are not readily available or are published in a number of different formats making comparisons between facilities difficult. This project is designed to bring this information together in one data base and make it accessible across Canada.

1.1 Project Objectives

The overall objective of the project is to develop a computer data base containing as much historical design information and current operational data from the various Canadian anaerobic digestion facilities and to make this information available to government personnel, engineering firms, industries and individuals attempting to design or evaluate this technology.

The specific objectives of the project are as follows:

1. Phase I - Develop an inventory of Canadian anaerobic digestion systems and establish a computerized data base that will contain the historical design data.

2. Phase II - Develop and implement a long term monitoring and data collection program for Canadian anaerobic digestion systems. The information collected will be used to update the data base.

3. Phase III - Prepare and present the project concept at the Fourth International Symposium on Anaerobic Digestion in Guangzhou, China.

4. Phase IV - Implement the long term monitoring and data base management programs.

5. Phase V - Transfer the acquired information through liaison with other organizations and countries.

6. Phase VI - Prepare statistical summaries and an annual report.

The specific objectives of this interim report are as follows:

1. Describe the development of the data base which contains data from anaerobic digestion systems in Canada.

2. Describe the long monitoring and data collection program for anaerobic digestion systems operating in Canada.

3. Describe the presentation of the project concept at the Fourth International Symposium on Anaerobic Digestion held in Guangzhou, China in November, 1985.

2.0 METHODOLOGY

2.1 Data Base Development

An inventory of anaerobic digestion systems in Canada was established by contacting federal and provincial government officials, universities, engineering firms and individuals involved in anaerobic digestion technology. An extensive literature review of project reports, presentations, journals and other publications was conducted.

From the contacts and literature available at the writing of this report, it appears that 15 full-scale anaerobic digestion systems have been constructed in Canada and that 2 systems are at the design or construction stage.

To assist in the collection of the design and historical data for each of the facilities, a standard questionnaire was developed. Information available from the literature was filled in by CANVIRO personnel and the questionnaire was mailed to the appropriate contact person for each digestion system for verification of the data and completion of the information. A copy of the questionnaire is contained in Appendix A.

The data collected from the questionnaire was compiled into a standard format and entered into ASCII data files on an IBM-PC. This information was edited and then uploaded from the data files to the appropriate conference and topic in the data base.

2.2 CoSy Operating System

The CoSy (Conferencing System) developed and operated by the University of Guelph was selected for the storage of the data base. The CoSy system was selected because it is currently being used for a wide variety of similar conferences, is relatively user friendly and is accessible Canada wide through DATAPAC, TYMNET and TELENET.

2.3 Long Term Monitoring Program

A long term monitoring program is currently being established to obtain current operational data and operator comments, questions, suggestions and concerns about anaerobic digestion technology. The program will consist of obtaining copies of operational monitoring sheets and records from sites where this information is collected and recorded and through monthly sampling, where no operational records are currently being kept.

3.0 RESULTS AND DISCUSSION

3.1 Full-Scale Anaerobic Digestion System Inventory

Full-scale Canadian anaerobic digestion facilities, are listed in Table 1.

3.2 Organization of CoSy Data Base

The CoSy Computer Conferencing System is organized into Conferences, which contain Topics, which in turn contain Messages. The organizational structure of the Canadian Anaerobic Digestion System Data Base is illustrated in Figure 1. The data base contains six Conferences. Each Conference (except INTRO) contains 15 Topics, one for each anaerobic digestion facility. CoSy "Topic Names" are listed in Table 2. New information is added to a Topic in the form of a new Message. The six data base Conferences are as follows:

1. Introduction (INTRO)
   This conference is an introduction to the data base. It contains a list of the Conferences and a brief description of each.

2. Digester Design Information (DIGESTERDESIGN)
   This conference contains technical design information about anaerobic digestion systems operating in Canada. Information, such as digester design characteristics (digester type and size, hydraulic retention time, operating temperature, loading rate, etc.), biogas utilization, costs (capital, operation and maintenance, and estimated savings) and design and operation problems is included.

3. Current Operating Conditions (OPCONDITIONS)
   This conference contains information about the current operating conditions at each site and operator notes and observations.

4. Monthly Data Report (MONTHREPORT)
   Information on current operating performance, such as biogas production and quality, operating temperatures, etc., recorded at the various sites, is summarized monthly.

TABLE 1. CANADIAN ANAEROBIC DIGESTION FACILITIES

FACILITY	LOCATION	TYPE OF OPERATION	WASTE TREATED	DIGESTER TYPE
1. Agroupur Cooperative Agro-Alimentaire	Notre-Dame-du-Bon-Conseil, Quebec	Cheese Plant	Plant Wash Water	(i) Downflow Stationary Fixed Film (ii) Upflow Anaerobic Sludge Blanket
2. Buteau and Tremblay Farm (CRIQ)	St. Henri-de-Levis, Quebec	Farm	Swine Manure	Fixed Film
3. Cattleland Ontario Ltd.	Petersburg, Ontario	Farm	Beef Cattle Manure	Completely Mixed
4. Fallis Farm	Millbrook, Ontario	Farm	Swine Manure	Completely Mixed
5. Folkema Farm	Ingersoll, Ontario	Farm	Swine Manure	Fixed Film
6. Gasser Farms Ltd.	St. Pierre-de-Veronne-a-Pike-River, Quebec	Farm	Dairy Cattle Manure	Mixed Plug Flow
7. Industrial Grain Products, a division of John Labatt Ltd.	Thunder Bay, Ontario	Wheat Starch Plant	Wheat Starch Processing Waste	Completely Mixed
8. Kemptville College of Agricultural Technology	Kemptville, Ontario	College Farm	Beef Cattle Manure	Completely Mixed (originally) Fixed Film)
9. Linden Lee Farms	Cornwall, P.E.I.	Farm	Swine Manure	Completely Mixed
10. McCain Foods Ltd. (under construction)	Florenceville, New Brunswick	Food Processing Plant	Potato Processing Waste	Anaerobic Contact Process
11. Millbank Cheese and Butter Ltd.	Millbank, Ontario	Cheese Plant	Cheese Whey	Completely Mixed
12. Olds College	Olds, Alberta	College Farm	Swine and Dairy Cattle Manure	Not Available
13. Pittens Farms Ltd.	Cambridge, Ontario	Farm	Dairy Cattle Manure	Completely Mixed
14. Selves Farms Ltd.	Fullarton, Ontario	Farm	Swine Manure	Completely Mixed
15. University of Guelph, Arkell Research Station	Guelph, Ontario	University Farm	Swine Manure	(i) Completely Mixed (ii) Completely Mixed

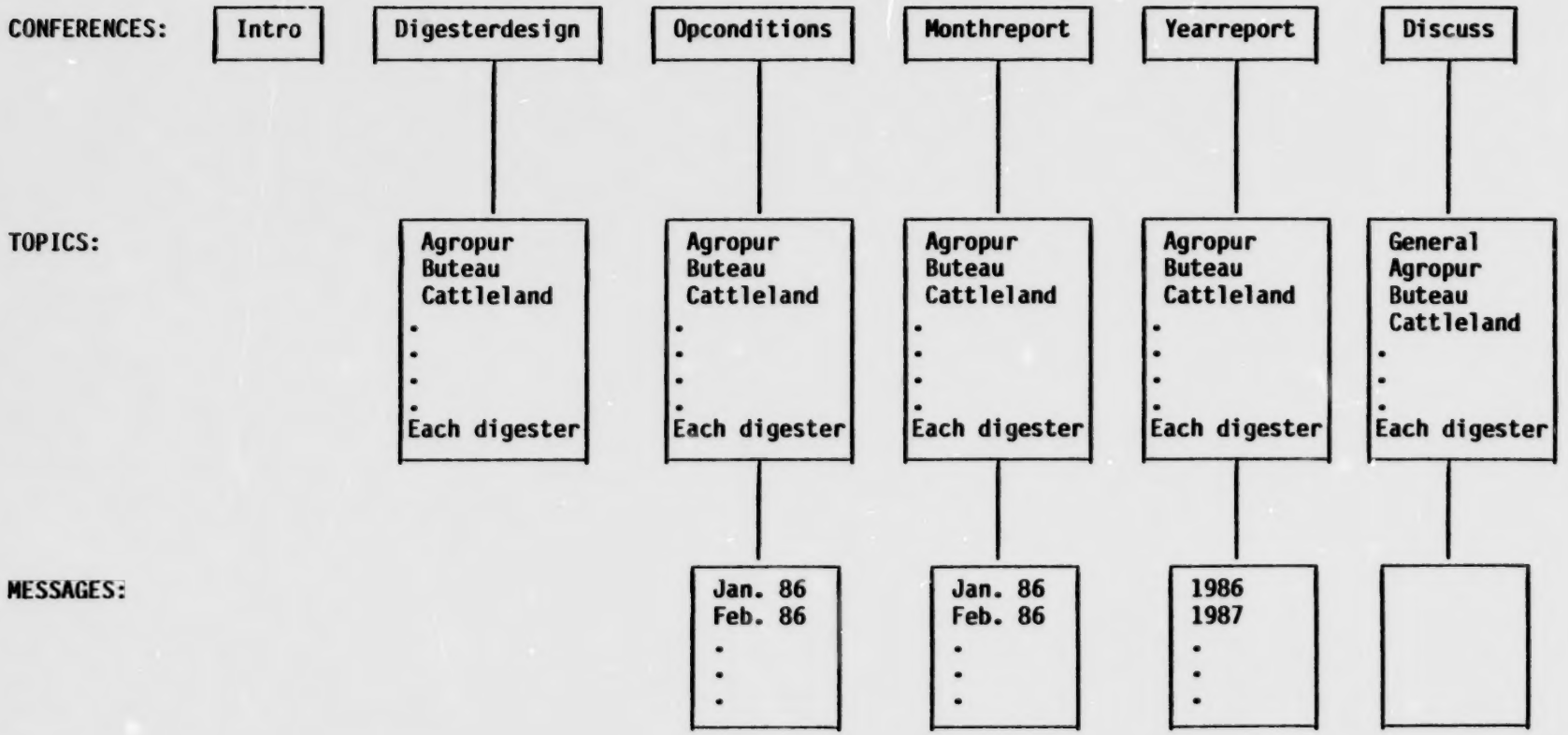


FIGURE 1 - ORGANIZATIONAL STRUCTURE FOR THE CANADIAN ANAEROBIC DIGESTION DATA BASE

TABLE 2. CoSy TOPIC NAMES

	Anaerobic Digestion Facility	CoSy Topic Name
1.	Agropur Cooperative Agro-Alimentaire	AGROPUR
2.	Buteau and Tremblay Farm	BUTEAU
3.	Cattleland Ontario Ltd.	CATTLE
4.	Fallis Farms	FALLIS
5.	Folkema Farm	FOLKEMA
6.	Gasser Farm	GASSER
7.	Industrial Grain Products	GRAIN
8.	Kemptville College of Agricultural Technology	KEMPTVILLE
9.	Linden Lee Farms	LINDEN
10.	McCain Foods Ltd.	MCCAIN
11.	Millbank Cheese and Butter Ltd.	MILLBANK
12.	Olds College	OLDS
13.	Pittens Farms Ltd.	PITTENS
14.	Selves Farms Ltd.	SELVES
15.	University of Guelph	GUELPH

5. Yearly Data Report (YEARREPORT)
   Data collected at the various sites will be summarized yearly from the monthly reports.

6. Discussion Forum (DISCUSS)
   Questions, comments and queries can be entered on the data base by users.

The procedures to log on to CoSy and to access the data base are outlined in Appendix B.

3.3 Questionnaire Responses

Questionnaires were sent to appropriate contact persons involved with each anaerobic digestion facility, to be reviewed and completed. Questionnaires sent to Industrial Grain Products, and Olds College had not been returned at the writing of this report. The information on the data base relating to the Industrial Grain Products facility was obtained from publications and has not been reviewed. There is no information available on the data base for Olds College. A letter was received from Agriculture Canada

indicating that they were not in a position to complete or review the partially completed questionnaires that were sent to them, regarding Fallis Farm and Folkema Farms. The data base, therefore, only contains information found in publications for these 2 locations. Questionnaires from all the other sites were reviewed, completed and returned by the appropriate contact persons.

Currently, the following digesters are not operating: Agropur, Cattleland Ontario Ltd., Fallis Farm, Folkema Farm, Linden Lee Farms, McCain Foods Ltd (under construction), Pitten's Farms Ltd. (start-up due shortly), and the University of Guelph 45 m^3 digester.

3.4 Monitoring Program

The monitoring and data collection program started in January 1986. The information obtained from the sampling program will be added to the data base as results beccome available.

A typical data log sheet located at each anaerobic digestion site is shown in Table 3. Individual log sheets were designed for each site depending on the type of facility. The digester operator is requested to fill in the required information daily. For the operational and performance parameters not being recorded on-site, a sampling program was established. Shipping cartons containing six 500 mL plastic sample bottles (3 for digester influent and 3 for digester effluent samples) and biogas sampling bags were made up. Digestion plant operators are requested to take samples once a month and ship the sampling cartons as well as the monthly data log sheets, to CANVIRO's Kitchener office for laboratory analysis. The data base will be updated once a month with the monitoring results and the operational log sheet information. This information will be contained in the MONTHREPORT Conference on the data base.

The data contained in the MONTHREPORT Conferences will be summarized for each site at the end of each year and placed in the YEARREPORT Conference and a new MONTHREPORT Conference will be started. Examples of the MONTHREPORT and YEARREPORT format are shown in Tables 4 and 5, respectively.

TABLE 3. TYPICAL ANAEROBIC DIGESTION AND ELECTRICAL CO-GENERATION SYSTEM OPERATIONAL LOG SHEET

Anaerobic Digestion Facility Name and Location:

DATE	TIME	INFLUENT FLOW (m^3/d)	DIGESTER TEMP. (°C)	GAS READING (m^3/d)	kW-HR PRODUCED	SCP RECOVERED (TONNES)	COMMENTS

TABLE 4. MONTHREPORT CONFERENCE

The following is a summary of results obtained for the month of _____,

19XX at XXX:

DIGESTER LOADING RATES:

Average Digester Temperature (deg C):
Total Volume (L/d):
Specific Loading Rate (kg VS/m^3 digester·d):
Specific Loading Rate (kg COD/m^3 digester·d):
Hydraulic Retention Time (d):

DIGESTER INFLUENT DATA:

pH:
TS (mg/L):
TVS (mg/L):
COD (mg/L):

DIGESTER EFFLUENT DATA:

pH:
TS (mg/L):
TVS (mg/L):
COD (mg/L):

DIGESTER BIOGAS PRODUCTION DATA:

Flowrate (m^3/d):
Methane content (%):
Specific Gas Production Rate (m^3/kg VS·d):
Specific Gas Production Rate (m^3/kg COD·d):
Biogas (m^3 biogas/m^3 digester·d):

ENGINE CO-GENERATION SYSTEM:

Hours of Operation (hr):
Average kW-hr Production (kW-hr/d):
Total Monthly kW-hr Production (kW-hr/month):
Average Specific Fuel Consumption (m^3 biogas/kW-hr):

SCP RECOVERY SYSTEM:

Hours of Operation (hr):
Average Quantity Recovered (tonne):

TABLE 5. YEARREPORT CONFERENCE

The following is a summary of results obtained for 198X at XXXXXXXX

DIGESTER LOADING RATES:

Average Digester Temperature (deg C):
Total Volume (L/d):
Specific Loading Rate (kg VS/m^3 digester·d):
Specific Loading Rate (kg COD/m^3 digester·d):
Hydraulic Retention Time (d):

DIGESTER INFLUENT DATA:

pH:
TS (mg/L):
TVS (mg/L):
COD (mg/L):

DIGESTER EFFLUENT DATA:

pH:
TS (mg/L):
TVS (mg/L):
COD (mg/L):

DIGESTER BIOGAS PRODUCTION DATA:

Flowrate (m^3/d):
Methane content (%):
Specific Gas Production Rate (m^3/kg VS·d):
Specific Gas Production Rate (m^3/kg COD·d):
Biogas (m^3 biogas/m^3 digester·d):

ENGINE CO-GENERATION SYSTEM:

Hours of Operation (hr):
Average kW-hr Production (kW-hr/d):
Total Monthly kW-hr Production (kW-hr/month):
Average Specific Fuel Consumption (m^3 biogas/kW-hr):

SCP RECOVERY SYSTEM:

Hours of Operation (hr):
Average Quantity Recovered (tonne):

From the comments section on the data log sheets, a summary will be made of the current operating conditions at the site. This information will be contained in the OPCONDITIONS Conference on the data base. An example of the OPCONDITIONS Conference, in the format in which it appears on the data base, is shown in Table 6.

TABLE 6. OPCONDITIONS CONFERENCE

Anaerobic Digestion Facility:
Type of Waste Treated:
Date:
Month/Year:
Current Operating Conditions:

The DISCUSS Conference is a summary of comments made by users of the data base to the moderator, other users or general observations about any topic. The Conference is divided into summaries of comments made on each anaerobic digestion facility. The procedure to follow to make a comment is outlined in Appendix B.

3.5 Presentation of Project Concept at the Fourth International Symposium on Anaerobic Digestion

The Fourth International Symposium on Anaerobic Digestion was held in Guangzhou, China from November 11th to 15th, 1985. The symposium was designed to be an international forum in which representatives from over 46 countries participated in an exchange of information through seminars, presentations and poster sessions. CANVIRO Consultants Ltd. prepared posters illustrating representative anaerobic digestion facilities operating on agricultural and industrial wastes in Canada. Photographs and brief technical descriptions of the systems were included on each poster. The posters were intended to display the state of anaerobic digestion technology in Canada. A poster was also prepared to present the data base concept to other countries and to develop contacts with other governments and organizations interested

in promoting the concept in their countries. Energy, Mines and Resources personnel lead discussions and meetings with several international agencies. As a result of their efforts, contacts have been established with officials from the Chinese Academy of Science, Guangzhou Institute of Energy Conservation, Beijing Municipal Research Institute of Environmental Protection, Zhejiang Province Research Institute for Biogas and Solar Energy, the Chinese Academy of Agricultural Engineering Research and Planning and the University of Lisbon, Portugal. Numerous contacts were established with people interested in accessing the data base. The countries that specifically expressed interest were China, Norway, Belgium, Austria, United States, Ireland, Portugal, India and Germany.

4.0 DIGESTER DESIGN INFORMATION

The digester design information presented in this Section is in the format in which it appears on the COSY Conferencing System data base. As discussed in the previous section, design information is contained in the DIGESTERDESIGN Conference.

4.1 Agropur Cooperative Agro-Alimentaire

A) GENERAL INFORMATION

Name: Agropur Cooperative Agro-Alimentaire

Address (Digester Location): 81 rue St. Felix
Notre Dame du Bon Conseil, Quebec
CANADA

Address (Agropur Head Office): 510 rue Principale
Case Postale 6000
Granby, Quebec
J2G 7G2
CANADA

Telephone Number: (514) 375-1991

Contact Persons: Roeland Peters and Claude Hade

Start-Up Date: April 1983

Engineering Design: Agropur Cooperative Agro-Alimentaire
510 rue Principale
Case Postale 6000
Granby, Quebec
J2G 7G2
CANADA

Telephone Number: (514) 375-1991
Contact Persons: Roeland Peters and Claude Hade

and

Engineering Design: Euroconsult
Lavinklaan 1, Arnhem
Postbus, 264
6800 A G Arnhem
THE NETHERLANDS

Telephone Number: 085-778899
Contact Person: Dr. Ir. J. A. Zaevalkink

Type of Operation: Cheese Plant
Type of Waste: Plant Wash Water

Objectives of Digesters and Treatment Facility: To treat the plant's wash water to an environmentally acceptable level and discharge it to a river.

B) PROCESS DESCRIPTION

A pumping station pumps effluent from the cheese factory to the wastewater treatment plant. The station is of fibreglass construction and is equipped with 3 acid resistant submersible pumps. At the treatment plant a solid removal system removes large suspended solids (>5 mm). The system was constructed with a rotary screen just before the the grit removal system. A canal 6 m x 0.5 m is used to remove the grit. The flow in the canal is kept constant by a Sutro proportional weir. An equalization tank equipped with a pH control system is used to avoid large pH fluctuations in the feed. Three submersible mixers are used. The pH is controlled using hydrated lime and hydrochloric acid.

The system is made up of two anaerobic digesters. The first digester, a 400 m^3 downflow stationary fixed film type (DSFF),uses 19,600 fired clay blocks as support material for bacterial growth. The reactor is covered by a dome which maintains a constant pressure. Wastewater feeding and recirculation is accomplished by an arrangement of ABS plastic pipes located at the top and bottom of the reactor. The second digester is a 400 m^3 upflow anaerobic sludge blanket (UASB) type. In this reactor, the feed is entered through the bottom and passed up through the granular sludge. The domes at the top of the reactor are designed to separate the treated effluent and the biogas. The effluent from the DSFF and UASB reactors is collected in a sedimentation tank. Any bacterial sludge escaping from the reactors is settled and stored in the sedimentation tank for return to the reactors periodically. The anaerobically treated effluent is passed through four oxidation ponds in order to reduce the BOD for discharge to the river. The four oxidation ponds are aerated with fine bubble type aerators. The effluent then proceeds to two sedimentation ponds to further reduce the amount of solids. From the sedimentation ponds, the effluent is discharged (by gravity) into the Nicolet River.

C) DIGESTER CHARACTERISTICS

Type: i) Downflow Stationary Fixed Film (DSFF)
Fixed Film Media: Fired clay blocks
ii) Upflow Anaerobic Sludge Blanket (UASB)

Size: Active Volume: DSFF - 8.4 x 10.0 x 7.0 m ht. = 588 m^3 - block space
= 400 m^3 liquid volume
UASB - 7.0 x 10.0 x 7.0 m ht. = 400 m^3 liquid volume

Design Hydraulic Retention Times: DSFF 12 hours
UASB 12 hours

Operating Temperatures: 30 deg C

Design Loading Rates: 7.0 kg COD/$m^3 \cdot d$

Digester Heating System: Washwater entering the digesters is at operating temperature.

Size of Gas Blower: 1.5 kW (2 HP)

Safety Equipment Used: The safety equipment consists of a gas sensor, which in the event of a gas leak, sounds an alarm in the control building, a flame arrester, a vacuum breaker and a pressure relief valve.

D) BIOGAS UTILIZATION

Biogas Use: To Partially Fuel a Boiler

Boiler Size: 36,300 kg/hr (80,000 lbs/hr)

Manufacturer: Babcock and Wilcox

Other Fuels Boiler Operates With: Natural Gas

Boiler Uses: Steam for plant use, such as milk heating, space heating, etc.

E) CAPITAL COSTS

Not available

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

A few mechanical problems have arisen (corrosion of some parts, corrosion of the concrete walls in the holding tank and the reactors, gas leaks through improperly sealed joints...). These problems have been solved by either repairing or replacing the faulty or damaged areas.

Problems with the fixed film media (fired clay blocks) were experienced. The channels in the blocks became plugged because they were improperly aligned. The fixed film media will be removed shortly and the digester may be converted to an upflow anaerobic sludge blanket type of reactor.

The reservoir tanks that hold the hydrochloric acid and the hydrated lime (used for pH control) were too small to hold the quantity of chemicals required and had to be replaced with larger ones.

PHOTOGRAPH 1. AGROPUR WASTEWATER TREATMENT FACILITY

4.2 Buteau and Tremblay Farm/CRIQ

A) GENERAL INFORMATION

Name: Ferme Buteau et Tremblay

Address: 415 Chemin Plaisance
St. Henri-de-Levis, Quebec
CANADA

Contact Person: Rock Buteau

Start Up Date: May 1985

Engineering Design: Centre de Recherche Industrielle du Quebec (CRIQ)

Address: 333 rue Franquet
Case Postale 9038
Ste. Foy, Quebec
G1V 4C7
CANADA

Telephone Number: (418) 659-1550

Contact Person: Paul Toupin

and

Engineering Design: Agriculture Canada

Address: Station de Recherche de St. Jean
Agriculture Canada
Case Postale 457
430 boulevard Gouin
St. Jean, Quebec
J3B 6Z8
CANADA

Telephone Number: (514) 346-4494

Contact Person: Roger Chagnon

Type of Operation: Farm

Type of Waste: Swine Manure

Number and Type of Animals: 3800 pigs total on farm, only manure from 1400 pigs used in the digester operation.

Type of Housing: Partially slatted floors

Feed Composition: Corn/soybean ration

Type of Manure Handling System: Partially slatted floors. Manure flows by gravity to a holding tank.

Objectives of Digester:

To demonstrate fixed film technology for energy production and odour reduction.

B) PROCESS DESCRIPTION

Manure is pumped from a storage tank through a 20 mesh Sweco vibrating screen separator to an influent holding tank where it is preheated to 35 deg C. The influent is pumped from the holding tank to the digester 6 times a day. Solids recovered from the separator are mixed with the digester effluent and pumped to an effluent holding tank.

The biogas produced is withdrawn from the digester and directed by a gas blower to a hypalon flexible storage bag. The biogas is used to fuel a boiler and an engine generator set. The hot water produced by the boiler is used to heat the digester and to provide hot water for the piggery and a nearby greenhouse. Electricity produced by the engine generator set is introduced into the power grid. Solids recovered from the screen separator are hauled to compost heaps and the digester effluent is pumped to a 530 m^3 holding tank and is later spread on the land.

C) DIGESTER CHARACTERISTICS

Type: Downflow Stationary Fixed Film
Fixed Film Media: Mechanically Roughened PVC Sectioned Tubing

Size: Active Volume: 50 m^3
Diameter: 3.66 m
Height: 6.10 m

Design Operating Temperature: 35 deg C

Design Loading Rate: 7.0 kg VS/m^3·d
17.0 kg COD/m^3·d

Design Retention Time: 5 days

Mixing System: The digester contents are mixed every 15-30 minutes by circulating the contents from the bottom of the digester to the top

Mixing Energy Input: 1.1 kW (1.5 HP)

Heat Exchange System: Hot water is circulated through 2 main beams supporting the grid.

Biogas Storage: Type: Hypalon 5 ply flexible bag contained in two steel tanks that have been welded together

Location With Respect To Digester: approx. 5.5 m away

Capacity: 80 m^3

Pressure: 0.1 kPa (8 mm water)

Size of Gas Blower: 40 m^3/hr maximum

Safety Equipment Used:

Three biogas sensors are located in the digester control building. In the event of a leak, a shut-off valve inhibits the gas flow, an alarm, linked to the farm house is sounded and the ventilation system, consisting of two 14.2 m^3/min (500 cfm) fans located on the upper and lower levels of the digester control building, is activated.

D) BIOGAS UTILIZATION

Biogas Uses: To Fuel a Boiler and an Engine Generator Set

Biogas Scrubbing Method: New granules developed by CRIQ are to be used to remove hydrogen sulfide.

Boiler Size and Type: 59 kW (200,000 BTU/hr), BNH-200

Boiler Manufacturer: F.P. Industries

Boiler Uses: Water heated by the boiler is used to heat the digester, and to provide hot water for the piggery and a nearby greenhouse.

Engine Size and Type: Internal combustion, 15 kW

Manufacturer: Waukesha model VRG-155 U

Other Fuels Engine Operates With: Natural gas and propane

Generator Size and Type: 7.5 kW, 230 volt, 1 phase, 60 cycle, 1725 rpm, induction type.

Manufacturer: Doer model #91531

Uses of Electrical Power: Electricity is introduced to the farm power grid as produced to displace purchased power. No provision was made to sell power to Quebec Hydro.

Electrical Power Generation: 180 kW·hr/day

Heat Recovery System:

Heat is recovered from the engine cooling jacket via a No. 54-443-B-1003, 21 kW (1185 BTU/min) heat exchanger and from the exhaust gas via a gas/water heat exchanger designed by the Centre de Rechuche Industrielle du Quebec consisting of four pipes, 10.2 cm (4 inches) in diameter, arranged in series.

E) CAPITAL COSTS

Not available

F) OPERATION AND MAINTENANCE COSTS

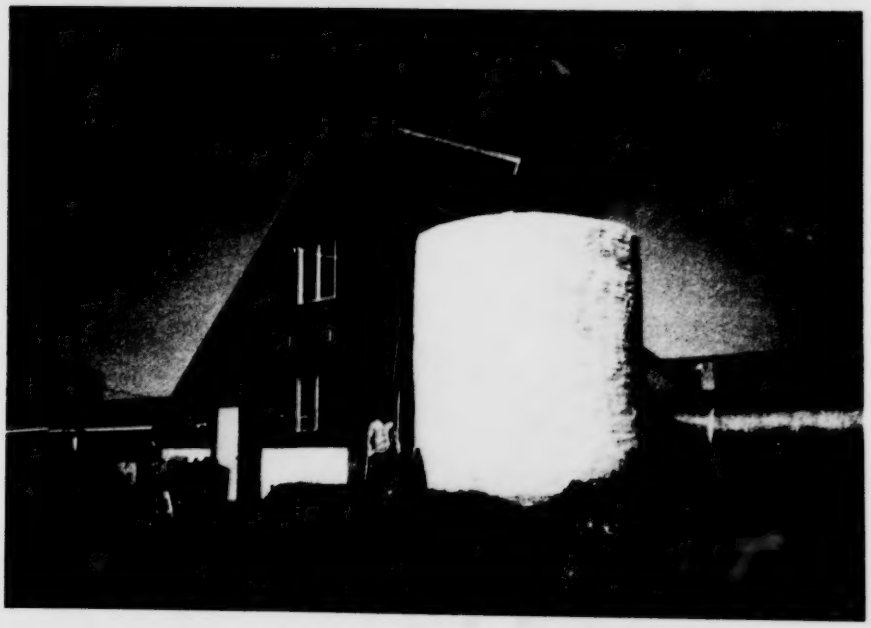
Not available

G) ESTIMATED SAVINGS

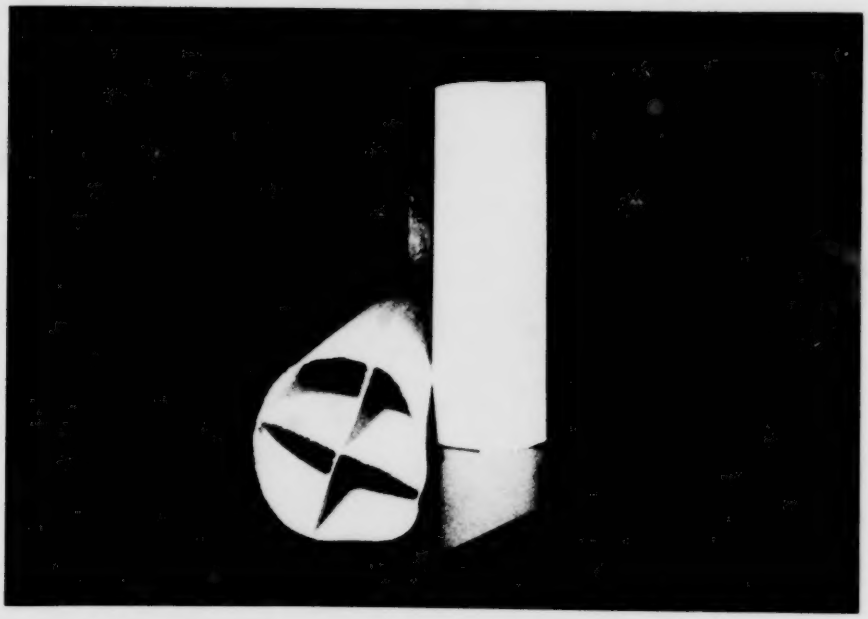
Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

The slope in the bottom conical section of the digester was not great enough (12 degrees) causing solids to build up. A scraper was designed and installed to remove the solids from the bottom of the digester.



PHOTOGRAPH 2. BUTEAU AND TREMBLAY ANAEROBIC DIGESTION FACILITY



PHOTOGRAPH 3. MECHANICALLY ROUGHENED PVC FIXED FILM MEDIA

4.3 Cattleland Ontario Ltd.

A) GENERAL INFORMATION

Name: Cattleland Ontario Ltd. (Formerly, Roslyn Park Farm Ltd.)

Address: R.R. #2
Petersburg, Ontario
N0B 2H0
CANADA

Telephone Number: (519) 696-3111

Contact Person: Bob Bechtel

Start-Up Date: November 1980

Engineering Design: Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5M5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: Farm

Type of Waste: Beef Cattle Manure

Number and Type of Animals: 4500 beef cattle

Type of Housing: Open sided, slatted floor barns

Feed Composition: By-products from food processing plants

Feeding Routine: Animals are fed in total confinement

Type of Manure Handling System:

Manure is pumped from pits located under the slatted floor barns to a solid bowl centrifuge to separate out solids. The liquid then flows by gravity to a holding tank and is pumped continuously from there to the digester.

Objective of Digester: Odour control

B) PROCESS DESCRIPTION

The system was designed to be integrated into the existing manure handling system at the farm (i.e. initial solid/liquid separation; solids composting and liquid storage-spray irrigation). The liquid from the first centrifuge flows by gravity to a holding tank and is pumped continuously from there to the digester with a variable speed progressing cavity pump.

The system was designed to operate at either thermophilic (55-60 deg C) or mesophilic (35 deg C) temperatures. Steam is generated by a 60 kW dual-fuel boiler designed to switch automatically between biogas and propane auxiliary fuel when required.

Steam is used to bring the manure up to the process operating temperature prior to entering the digester. To make up for heat losses from the digester, steam is also injected directly into the digester to maintain the process temperature.

Biogas is withdrawn from the digester, cooled in a water jacketed heat exchange pipe, then passed through: a sediment/drip trap to remove grit and moisture; a gas meter to monitor biogas production; a gas blower to pump the biogas to steel storage tanks. The biogas flows automatically to the boiler on demand.

A propane auxiliary fuel system is provided for system start-up and periods when insufficient biogas is produced. When the system boiler does not require biogas, a flare is provided to burn the excess biogas.

Digester effluent is withdrawn from the tank bottom and pumped directly to the protein recovery unit, which consists of a second centrifuge with polymer conditioning system. Recovered single cell protein is conveyed to a farm truck for transportation to storage for refeeding as a ration protein supplement.

The final, processed liquid manure from the protein recovery system is pumped to the earthen storage for spray irrigation as a fertilizer.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 635 m^3
Diameter: 9.1 m
Height: 11.0 m

Design Operating Temperature: 35 deg C mesophilic and 55 deg C thermophilic

Design Hydraulic Retention Time: 10 days

Design Loading Rate: 4.3 kg VS/m^3·d

Digester Mixing System: The digester contents are continuously mixed with a turbine type, low rpm, low HP, top mounted mixer, rotating at 8.3 rpm. Baffles made of pressure treated wood were installed vertically inside the digester to promote more efficient mixing.

Digester Heating System: The digester influent is brought up to the process operating temperature of 35 degrees C prior to entering the digester by mixing steam and manure in a specially designed steam box. Steam is also injected directly into the digester to make up for heat losses and to maintain the process temperature.

Storage: Type: Low pressure steel tank
Capacity: 45 m^3
Pressure: 34.5 kPa (5 psig)

Size of Gas Blower: 4 m^3/min @ 13.8 kPa (143 cfm @2 psig)

Safety Equipment Used: CSA approved gas safety equipment is installed, as well as pressure and temperature controls.

D) BIOGAS UTILIZATION

Biogas Use: To Fuel a Boiler

Boiler Type and Size: 60 kW dual-fuel

Manufacturer: York Shipley

Other Fuels Boiler Operates With: Propane

Boiler Uses:

1. Maintain manure at process operating temperature prior to entering digester.
2. Make up for digester heat losses by injecting steam directly into digester.

E) SINGLE CELL PROTEIN RECOVERY SYSTEM

Recovery Method:

Digester effluent is withdrawn from the tank bottom and pumped directly to the protein recovery unit which consists of a second centrifuge (first centrifuge used as an initial solid/liquid separation before entering the digester) with a polymer conditioning system. The protein and phosphorus containing cake is concentrated from approximately 4% dry mater to 20% dry matter in the centrifuge. Recovered Single Cell Protein is conveyed to a farm truck for transportation to storage for feeding as a ration protein supplement. The effluent from the centrifugation operation is pumped to earthen storage for spray irrigation as fertilizer.

Centrifuge Type: Solid bowl scroll

Manufacturer: Sharples PM50000

G Force: 2000 x G

Bowl Speed: 2600 rpm

Bowl Diameter: 61.0 cm

Bowl Length: 182.9 cm

Polymer: Type: Percol 757
Dosage: 2.5 kg/tonne
Feedrate: 0.136 m^3/min

F) CAPITAL COSTS

SITE PREPARATION	$ 2,593.00 CDN
WASTE FEED SYSTEM:	
Manure feed system	8,424.00
Boiler water treatment system	8,211.00
Boiler water preheat and control system	9,471.00
Boiler and gas train	30,616.00
Steam heating system	1,343.00
DIGESTION TANK SYSTEM:	
Digestion tank (baffle, fittings etc...)	52,747.00
Digestion tank mixer	32,635.00
BIOGAS STORAGE AND UTILIZATION SYSTEM:	
Biogas collection and storage system	15,735.00
PROTEIN RECOVERY SYSTEM:	
Protein recovery system	165,684.00
Controls and instrumentation	4,407.00
BUILDING CONSTRUCTION	19,286.00
MECHANICAL INSTALLATION	37,738.00
ELECTRICAL INSTALLATION	12,915.00
ENGINEERING DESIGN	74,771.00
ACCOUNTING LEGAL AND FREIGHT	389.00
TOTAL CAPITAL COST	$ 476,965.00 CDN

G) OPERATION AND MAINTENANCE COSTS

OPERATING COSTS:

Repairs	$ 737.00 CDN
Maintenance - Supplies	21.00
Electricity	3,775.00
Boiler feed chemicals	754.00
Polymer (4 months of operation)	2,916.00
Miscellaneous supplies and auxiliary fuel	1,071.00
LABOUR COSTS:	
Labour (1/2 man year @ $16,000/yr)	8,000.00
Fringe benefits (estimated 15% of direct labour)	1,200.00
Employment Expense	200.00
TOTAL OPERATING AND MAINTENANCE COSTS	$ 18,674.00/YR CDN

H) ESTIMATED SAVINGS

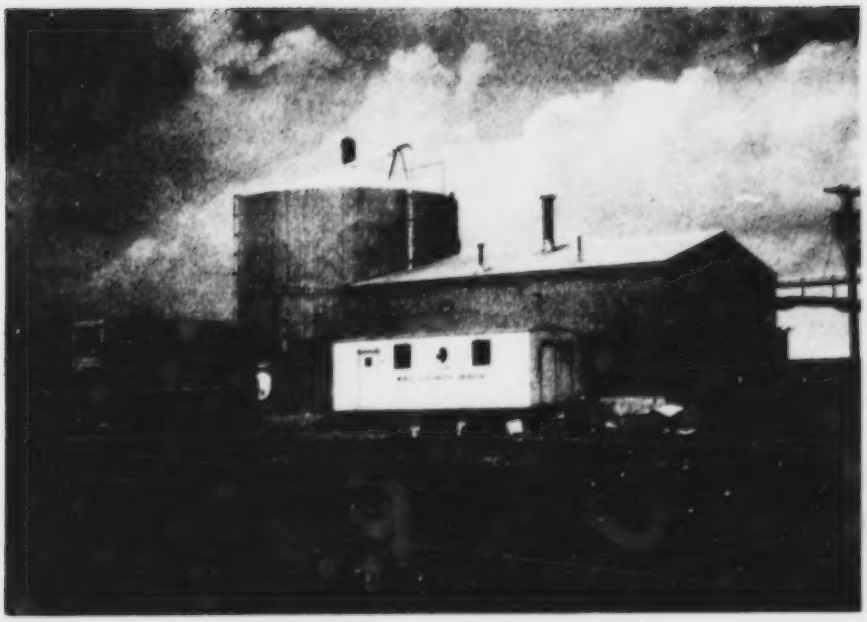
Space heating	$ 1,600.00 CDN
Protein recovery	28,320.00
TOTAL ESTIMATED SAVING	$ 29,920.00/YR CDN

I) SYSTEM PROBLEMS AND SOLUTIONS

The system was originally designed to operate thermophilically but performed equally well mesophilically and has operated at 35 degrees C for the last few years.

Foaming was a problem from time to time during the spring and fall (usually when runoff changes the manure concentration). A mechanical foam breaker was designed and installed alleviating the problem.

The failure of electrical and electronic components was a constant problem during the first few years. All copper components failed every 6-8 months from corrosion until most of them were replaced with mechanical equivalents.



PHOTOGRAPH 4. CATTLELAND ONTARIO LTD. ANAEROBIC DIGESTION FACILITY

4.4 Fallis Farm

A) GENERAL INFORMATION

Name: Fallis Farms

Address: Millbrook, Ontario
CANADA

Start-Up Date: 1978

Engineering Work: Agriculture Canada

Address: Engineering and Statistical Research Institute
Research Branch, Agriculture Canada
Ottawa, Ontario
K1A 0C6
CANADA

Telephone Number: (613) 995-9671

Contact Person: Peter Van Die

Type of Operation: Farm

Number and Type of Animals: 95 sows farrow-to-finish

Type of Waste: Swine Manure

Type of Manure Handling System:

Manure is collected in gutters and then pumped to a manure pit. Manure is pumped from the pit to the digester.

Objectives of System:

1. Treat manure.
2. Produce biogas to fuel a boiler.

B) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 107 m3
Diameter: 6.1 m
Height: 3.7 m

Design Operating Temperature: 35 deg C

Design Hydraulic Retention Time: 25 days

Digester Mixing System:

Consists of a modified compressor system equipped with phenolic blades and an"in-line" drip pocket and lubricator assembly.

Digester Heating System:

Consists of a heating grid 50 mm above the digester floor made of nominal 25 mm black iron pipe arranged in a series of 14 return loops. Each loop is approximately 8 m long and is connected to the boiler system located in the adjacent boiler building. A glycol mixture is used as the heat transfer liquid.

Safety Equipment Used: Explosion proof switches, fixtures and motors.

C) BIOGAS UTILIZATION

Biogas Use: To Fuel a Boiler

Boiler Size and Type: 39 kW (142,000 kJ/hr)

Manufacturer: Slant Finn G175-P

Other Fuels Boiler Operates With: Propane

Boiler Use: To maintain digester at process temperature of 35 deg C

D) CAPITAL COSTS

SITE PREPARATION	$ 581. CDN
DIGESTION TANK SYSTEM	
Concrete work hatches etc., materials and labour	5,382.
	1,930.
Insulation of digester - materials and labour	1,930.
Aeration system - materials and labour	2,377.
BIOGAS STORAGE AND UTILIZATION SYSTEM	
Boiler assembly, heating grid, controllers etc. - Materials and labour	4,549.

BIOGAS STORAGE AND UTILIZATION SYSTEM	
Boiler assembly, heating grid, controllers etc. - Materials and labour	4,549.
ELECTRICAL INSTALLATION	
Supplies, materials, labour and inspection	757.
OTHER	
Myers pump	350.
Water, delivered by truck	184.
Propane installation rental and 1605 L (353 gal.) liquid propane	275.
TOTAL CAPITAL COST	$ 16,385. CDN

E) OPERATION AND MAINTENANCE COSTS

Not available

F) ESTIMATED SAVINGS

Not available

4.5 Folkema Farm

A) GENERAL INFORMATION

Name: Folkema Farm

Address: Ingersoll, Ontario
CANADA

Start-Up Date: December 1983

Engineering Design: Agriculture Canada

Address: Engineering and Statistical Research Institute
Research Branch, Agriculture Canada
Ottawa, Ontario
K1A OC6
CANADA

Telephone Number: (613) 995-9671

Contact Person: Peter Van Die

and

Engineering Design: MacLaren Engineers

Address: 320 Adelaide St. South
London, Ontario
N5Z 3L2
CANADA

Telephone Number: (519) 686-5711

Contact Person: Derk Maat

Type of Operation: Farm

Type of Waste: Swine Manure

Number and Type of Animals: 150 sows farrowing

Type of Manure Handling System:

Gutter flush system to a holding pit and then pumped to an existing liquid manure holding tank.

Objectives of System:

1. Treat waste.
2. Produce biogas to fuel an engine/generator set.
3. Recover heat.
4. Recover Single Cell Protein.

B) PROCESS DESCRIPTION

Raw manure is conveyed from a stirred holding tank to a gravity screen separator via an air-driven variable speed diaphragm pump.

The solid fraction of the manure, composed mainly of undigested and semi-digested feed solids is recycled and mixed with a dry feed ration and refed to the gestating sow herd.

The liquid effluent enters a second holding pit from which the reactor is fed. The manure is preheated in a plate coil heat exchanger and fed directly to the reactor at 37 deg C.

The reactor features a stationary downflow fixed film anaerobic process. The reactor is filled with 100 mm diameter PVC sectioned tubing in a vertical alignment having mechanically roughened surfaces with 40 grooves per cm. The tubes are supported on a FRP grid.

The media in the reactor has a surface area to volume ratio of 100 m^2/m^3. The reactor is operated in the downflow mode with heated hog waste substrate entering the top of the reactor through flow distribution piping and effluent being discharged from the bottom cone of the reactor for either recirculation or discharge to treated effluent storage tanks.

The biogas is discharged from the reactor head space and is cooled and cleaned to remove any particulate matter and moisture and is then metered and conveyed to a flexible bag located in a separate 'A' frame structure for storage. Biogas is then drawn from either the bag or reactor via a small compressor to feed a dual-fueled propane/biogas engine generator set which produces electricity and waste heat.

The generator is of the induction type (variable rate of power output) and is connected directly into the Ontario Hydro grid. The engine generator set operates on a demand basis for electrical energy on the farm and if sufficient biogas is available (high pressure in the storage bag) it will export electrical energy to the Ontario Hydro grid under a special buy-back contract.

The engine generator set is equipped with a special energy recovery package and recovers waste heat from the exhaust gas and engine jacket. The waste heat is stored in a hot water storage tank which provides energy for manure heating and other on-farm uses independently of the engine generator set operation.

C) DIGESTER CHARACTERISTICS

Type: Downflow Stationary Fixed Film
Fixed Film Media: Mechanically Roughened PVC Sectioned Tubing

Size: Active Volume: 38 m^3

Design Operating Temperature: 37 deg C

Design Loading Rate: 7.5 kg COD/m^3·d

Biogas Storage: Type of Storage: Flexible bag constructed of XR5 material

Location With Respect To Digester: Located in a separate 'A' frame structure

Capacity: 80 m^3

Pressure: 2.4 kPa (10 inches W.C. max)

The generator is of the induction type (variable rate of power output) and is connected directly into the Ontario Hydro grid. The engine generator set operates on a demand basis for electrical energy on the farm and if sufficient biogas is available (high pressure in the storage bag) it will export electrical energy to the Ontario Hydro grid under a special buy-back contract.

E) BIOGAS UTILIZATION

Biogas Use: To Fuel an Engine Generator

Generator Size: 15 kW

Generator Type: induction

Other Fuels Engine Operates With: Propane

Uses of Electrical Power: On-farm use

Heat Recovery System:

Heat is recovered from the exhaust and engine jacket of the engine generator set. The waste heat is stored in a hot water storage tank and provides energy for manure heating and other on-farm uses.

F) PROTEIN RECOVERY SYSTEM

Crude Protein Content: 0.5-0.75% effluent

Recovery Method:

Protein recovery is possible at two points in the treatment process. Significant protein in the form of undigested feed solids is present in the rawmanure. This protein is extracted by the separator from the raw manure priorto digestion.

Protein recovery is also possible from the anaerobic reactor effluent. The protein consists of undigested feed particles and single-cell microbialbiomass from the reactor. This protein is utilized in a condensed form in a liquid feeding system.

G) CAPITAL COSTS

Not available

H) OPERATION AND MAINTENANCE COSTS

$ 5000. CDN/yr.

I) ESTIMATED SAVINGS

BIOGAS REVENUE

Electrical	$ 2,000. CDN
Heat	2,000.

PROTEIN REVENUE

Refeed Solids	15,000.
Effluent Solids	15,000.
TOTAL ESTIMATED SAVING	$ 34,000. CDN/YR

PHOTOGRAPH 5. FOLKEMA FARM ANAEROBIC DIGESTION FACILITY

4.6 Gasser Farms Ltd.

A) GENERAL INFORMATION

Name: Les Fermes E. Gasser et Fils Limitees

Address: St. Pierre-de-Verrone-a-Pike-River
Quebec
JOJ 1PO
CANADA

Contact Person: Jean or Rolf Gasser

Start-Up Date: October 1982

Engineering Design: Urgel Delisle et Associes

Address: 426 Chemin des Patriotes
St. Charles-sur-Richelieu, Quebec
JOH 2GO
CANADA

Telephone Number: (514) 584-2207

Contact Person: Michel Cournoyer

And

Engineering Design: Agriculture Canada

Address: Station de Recherche de St. Jean
Agriculture Canada
Case Postale 457
430 boulevard Gouin
St. Jean, Quebec
J3B 6Z8
CANADA

Telephone Number: (514) 346-4494

Contact Person: Roger Chagnon

Type of Operation: Farm

Type of Waste: Dairy Cattle Manure

Number and Type of Animals: 500 animals total, only manure from 200 dairy cows and 150 bulls is used in the digester operation.

Type of Housing: Free stall, partially slotted and partially scraped floors and no bedding.

Feed Composition: Hay and corn silage

Feeding Routine: Feed is available continuously. The troughs are replenished 3 to 4 times a day.

Type of Manure Handling System: The dairy cattle manure falls through the slatted floors and flows continuously to a holding tank. The heifer manure is scraped from the concrete floor and stored in the holding tank.

Objectives of System:

1. Produce biogas to power an engine generator set.
2. Treat waste to reduce odors and allow manure to be spray irrigated.
3. Recover waste heat.

B) PROCESS DESCRIPTION

The digester consists of a 600 m^3 concrete tank. The tank is insulated on all surfaces and is below ground level. The top is a reinforced concrete slab over which an insulated building was built to serve as a shed for the digester equipment and agricultural machinery.

A longitudinal wall, dividing the digester in half, was built and forces the manure to follow a U-shaped path. Biogas is injected through the bottom of the digester to mix the manure and to prevent a crust from forming. Because the manure flows in a U-shaped path and it is continuously mixed using the biogas, the digester is considered to be a mixed plug flow type.

The manure is pumped from the barn towards the pre-heating section of the digester, through the digestion sections and then pumped to a storage tank. Twice a year the effluent is spray irrigated.

All the biogas produced is used by an engine generator set to produce electricity to displace purchased power on the farm. No arrangements have been made to sell power to Quebec Hydro. Heat is recovered from the engine and is used primarily to maintain the digester temperature at 35 deg C. The surplus is used to heat the milking parlor, the calving room, the office and the milk room.

C) DIGESTER CHARACTERISTICS

Type: Mixed Plug Flow

Size: Active Volume: 600 m^3
Width: 10 m
Length: 20 m
Depth: 4 m (includes 1 m for gas storage)

Design Operating Temperature: 35 deg C

Hydraulic Retention Time: 25 days

Design Loading Rate: 2.54 kg VS/m^3·d

Digester Mixing System: Consists of a compressor which delivers biogas through 8 PVC pipes, 25 mm in diameter, positioned throughout the digester.

Digester Mixing Energy Input (kW): 6 kW (The same gas blower is used to mix the digester contents and to deliver biogas to the engine. 6 kW represents 75% of the blower's capacity. The remaining 25% is used to pressurize the biogas to fuel the engine.)

Digester Heating System: Hot water, used to heat the digester, obtains its heat from losses from the engine generator set and exhaust gas heat exchangers.

Storage: Type: Hypalon, 5 ply, 1.14 mm thick flexible bag covered by a shelter.

Location With Respect To The Digester: Behind the digester control building.

Capacity: 150 m^3
Pressure: 0-1 KPa (0 to 4 inches water pressure)

Size of Gas Blower: 7.5 kW

Safety Equipment Used: The safety system consists of a smoke detector and a heat detector. In the event of a gas leak or a fire, the smoke detector and heat detector alarms are sounded in the milking parlor and in one of the owners houses.

D) BIOGAS UTILIZATION

Biogas Use: To Fuel an Engine Generator Set

Generator Size and Type: 60 kW, 75 KVA
Manufacturer: Mandem
Engine Size and Type: F817GU
Manufacturer: Waukesha
Other Fuels Engine Operates With: Propane
Use of Electrical Power: On-farm use

Heat Recovery System: Heat losses from the engine generator set and the hot water storage tank are used to heat the digester building. Heat from the engine cooling jacket heats water through a heat exchanger. The hot water is stored in a tank and is used to heat the digester contents and the manure before it enters the digester. The hot water is also used to heat other buildings through a hot water circuit.

E) CAPITAL COSTS

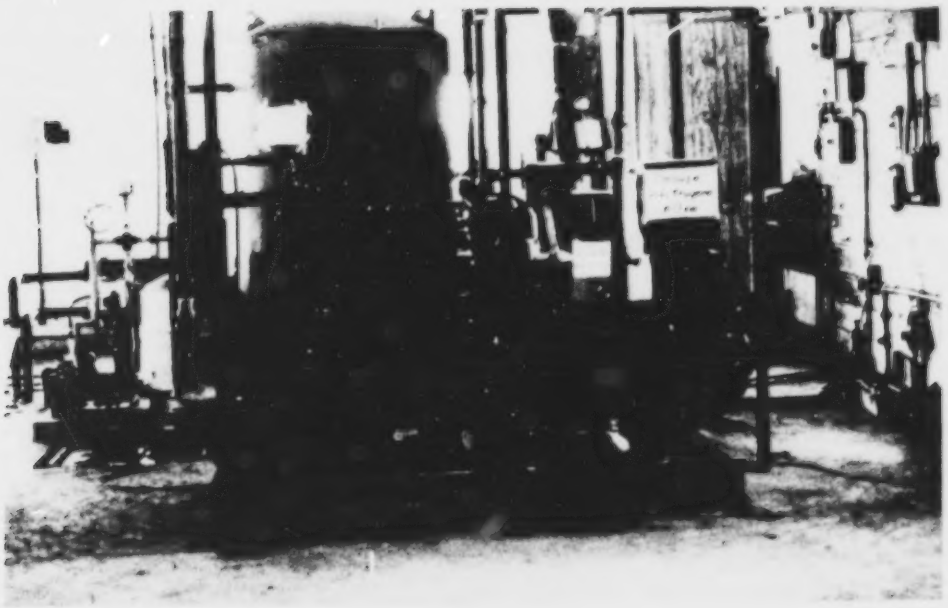
SITE PREPARATION	$ 5,000. CDN
WASTE FEED SYSTEM	3,500.
DIGESTION TANK SYSTEM	40,000.
BIOGAS HANDLING, STORAGE AND UTILIZATION SYSTEM	
Handling	10,500.
Storage	13,000.
Engine generator	38,000.
BUILDING CONSTRUCTION	20,000.
ELECTRICAL INSTALLATION	25,000.
ENGINEERING DESIGN	25,000.
TOTAL CAPITAL COST	$ 210,000. CDN

F) ESTIMATED OPERATION AND MAINTENANCE COSTS

	Year 1	Year 5	Year 10
REPAIRS			
Miscellaneous	$ 400. CDN	$ 500. CDN	$ 600. CDN
Motor	600.	1,000.	1,760.
MAINTENANCE	1,500.	2,650.	4,665.
LABOUR (SPECIALIZED)	500.	880.	1,550.
ELECTRICITY			
Supplies and miscellaneous	1,000.	1,760.	3,100.
TOTAL ESTIMATED OPERATION AND MAINTENANCE COSTS	$4,000. CDN	$6,790. CDN	$11,675. CDN

G) ESTIMATED SAVINGS

	Year 1	Year 5	Year 10
ELECTRICAL GENERATION	$12,100. CDN	$21,500. CDN	$37,800. CDN
HEATING COSTS	4,750.	6,390.	7,900.
TOTAL ESTIMATED SAVING	$16,850. CDN	$27,890. CDN	$45,700. CDN



PHOTOGRAPH 6. GASSER FARMS LTD. ENGINE/GENERATOR SET

4.7 Industrial Grain Products/John Labatt Ltd.

A) GENERAL INFORMATION

Name: Industrial Grain Products, a division of John Labatt Ltd.

Address: Thunder Bay, Ontario

Telephone Number: at J. Labatt Ltd. (head office)
451 Rideout North
London, Ontario
N6A 2P6
CANADA
(519) 673-5050

Contact Person: K. M. MacAuley

Start-Up Date: November, 1982

Engineering Design: Sorigona Inc.

Address: Woodbury, New York, 11797
U.S.A

Type of Operation: Wheat starch plant

Type of Waste: Wheat Starch Processing Waste

Objectives of Digester:

1. Remove major part of organic pollutants.
2. Produce biogas.
3. Remove odors.

B) PROCESS DESCRIPTION

The ANAMET process is an anaerobic-aerobic treatment system. It consists of an anaerobic contact reactor followed by an aerobic activated sludge plant.

In the process, the influent wastewater is first heated (or cooled) so that a desired treatment temperature of 35-37 degrees Celcius is maintained in the anaerobic reactors. The anaerobic reactor is a mechanically mixed, closed vessel in which a major portion of the organic material contained in the

wastewater is converted to biogas. The end products of the reaction are methane, carbon dioxide, synthesized microorganisms, and relatively simple organic compounds. The biogas generated in an anaerobic tank flows to a gas handling building for cleaning and preparation for on-site or other end uses. The gas system is also equipped with a flare to burn biogas generated that can not be used immediately.

The effluent from the anaerobic tank enters a degasification and flocculation tank to enhance subsequent solids settling. The mixture of treated wastewater and microorganisms is first mechanically mixed to shear biogas bubbles from suspended biomass. The biomass is then given opportunity to flocculate in a quiescent zone before entering an inclined plate settling device. In the settler most of the biomass is separated from the treated liquid and returned to the anaerobic tank. The supernatant from the inclined plate settler flows to an aerated tank or basin. The aeration stage serves as a polishing step to reduce any possible odors and to accomplish very high removals of BOD_5 (98% or greater).

Aerobic biological solids are separated in a final clarifier from which a certain amount of aerobic sludge is recycled to the aerobic tank in order to maintain design biomass concentration levels. The excess sludge from the aerobic stage is pumped to the anaerobic tank for digestion. Excess sludge from the total system is taken from the inclined plate settler underflow or from the anaerobic tank. Final effluent is discharged to a river.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 5700 m^3

Design Operating Temperature: 35-37 °C

Design Loading Rate: 3.0 kg COD/m^3·d maximum

Digester Mixing System: side mounted mixers are used

D) BIOGAS UTILIZATION

Biogas Use: To fuel a boiler

E) CAPITAL COST

Not available

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

TOTAL ESTIMATED SAVING	$150,000.00 /YR CDN

4.8 Kemptville College of Agricultural Technology

A) GENERAL INFORMATION

Name: Kemptville College of Agricultural Technology

Address: K.C.A.T.
Parish Building
Kemptville, Ontario
K0G 1J0
CANADA

Telephone Number: (613) 258-4671 or (613) 258-3411 extension 245

Contact Persons: Jody Barclay or Steve Vokey

Start-Up Date: November 1983

Engineering Design: Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5M5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: College Farm

Type of Waste: Beef Cattle Manure

Number and Type of Animals: 160 head beef cattle

Type of Housing: Open sided barn

Feed Composition:

Variable depending on experiments being conducted. Normally, 75% roughage (corn silage) and 25% grain (shelled corn or barley) dry matter basis.

Feeding Routine: Full feed once a day

Type of Manure Handling System:

Manure falls through the slatted floor into a holding tank under the barn. It is then pumped from a sump located adjacent to the barn to either the digester or one of the two concrete storage tanks.

Objectives of Digester:

To demonstrate the use of anaerobic digestion technology (originally fixed film; currently completely mixed) to produce energy and single cell protein for use at a typical beef operation and to provide the farming community with an opportunity to see and evaluate this technology with respect to their own operation.

B) PROCESS DESCRIPTION

The manure is pumped from a sump in the barn, through a Sweco vibrating screen separator, and into an influent holding tank. The digester is fed batch wise each day. A predetermined quantity of influent is pumped through the top of the digester, causing an equivalent quantity of effluent to overflow into an effluent holding tank. The effluent is pumped to a high speed solid bowl centrifuge where a polymer is injected and single cell protein is recovered. The waste liquid from the centrifuge is pumped to either the 356 m^3 or the 556 m^3 final concrete storage tank, where it can be stored for up to 6 months, before being spread on the farm land with a tanker spreader. The biogas produced is withdrawn from the digester and directed by a gas blower to a low pressure storage tank. It is used to fuel a propane/biogas hot water boiler which heats the digester contents and the control building.

C) DIGESTER CHARACTERISTICS

Type: Originally Fixed Film Converted to Completely Mixed Mesophilic
Fixed Film Media: Mechanically Roughened PVC Sectioned Tubing

** (Note: values in parenthesis apply to Completely Mixed System)

Size: Active Volume: 27 m^3
Diameter: 3.5 m
Height: 5.0 m

Design Operating Temperature: 35 deg C

Design Hydraulic Retention Time: 23 days (45 days)** see note above

Design Loading Rate: 3.0 (2.4) kg VS/m^3·d
3.3 (2.8) kg COD/m^3·d

Digester Mixing System: Digester contents are continuously mixed with a Flygt model 4400 portable submersible mixer.

Digester Mixing Energy Input: 2.4 kW

Digester Heating System: Water heated by the boiler is used to heat the digester contents

Biogas Storage: Type: Metal storage tank
Location With Respect to Digester: Adjacent to the digester, behind the control building.
Capacity: 22 m^3
Pressure: 34.5 KPa (5 psig)

Size of Gas Blower: 0.6 m^3/min (20 cfm)

Safety Equipment Used: Moisture trap, sediment trap, flame arrester, outside vent to air off excess gas

D) BIOGAS UTILIZATION

Biogas Use: To Fuel a Boiler

Boiler Size and Type: Hot water 69 kW (235,000 BTU/hr)

Manufacturer: York-Shipley

Other Fuels Boiler Operates With: Propane

Boiler Uses: Heat digester, control building and manure

E) SINGLE CELL PROTEIN RECOVERY SYSTEM

Recovery Method:

The digester effluent is pumped to a solid bowl scroll centrifuge as needed. A polymer is injected and the single cell protein is recovered in a single cell protein holding tank.

Centrifuge Type: Solid bowl scroll

Manufacturer: Sharples (Pennwalt) P660

G Force: 2900 G

Bowl Speed: 5100 rpm

Bowl Diameter: 15.2 cm

Bowl Length: 34.3 cm

Polymer: Type: Percol 757
Dosage: 2.5 kg/tonne
Feedrate: 1 L/min

F) CAPITAL COST

Not available

G) OPERATION AND MAINTENANCE COSTS

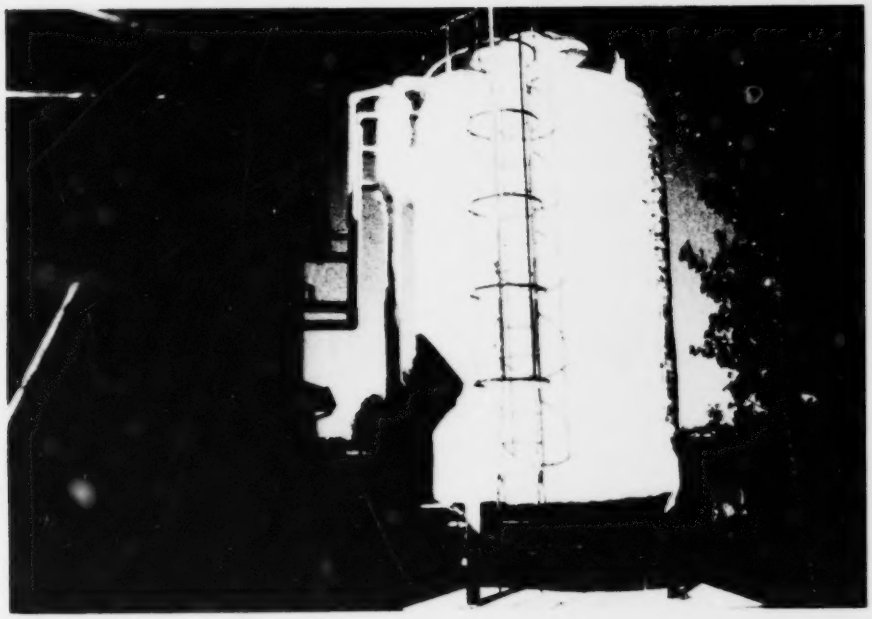
Not available

H) ESTIMATED SAVINGS

Not available

I) SYSTEM PROBLEMS AND SOLUTIONS

Problems with the fixed film media were experienced. Almost 80% of the tubes were blocked with undigested manure within a few months of start-up. The cause of the blockage is unknown. The fixed film media was removed from the full-scale digester which now operates as a completely mixed unit. A pilot-scale fixed film digester has been installed and is being operated under the same conditions as the full-scale unit prior to tube blockage. Media inspections are being conducted at regular intervals to determine possible causes of blockage.



PHOTOGRAPH 7. KEMPTVILLE COLLEGE ANAEROBIC DIGESTION FACILITY

4.9 Linden Lee Farms

A) GENERAL INFORMATION

Name: Linden Lee Farms

Address: R.R. #2
Cornwall, P.E.I.
COA 1HO
CANADA

Telephone Number: (902) 566-2740

Contact Person: Aike Wilting

Start-Up Date: August 1984

Engineering Design: Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5M5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: Farm

Type of Waste: Swine Manure

Number and Type of Animals: 200 sows farrow-to-finish

Feed Composition: Barley/wheat/rye/soybean ration

Type of Manure Handling System:

Finishing barn; partially slatted floor, shallow manure pit barn. The manure flows by gravity to a holding tank located at one end of the barn.

Objectives of Digester:

1. Pollution control.
2. Electrical generation.
3. Waste heat recovery.

B) PROCESS DESCRIPTION

Manure from the finishing barn, starter barn and neighbouring poultry and swine farm is pumped once daily to the digestion tank using the manure transfer pump. The digested liquid overflows through a gas/liquid trap assembly located on the digester to a nearby storage tank and lagoon.

The biogas is withdrawn from the digestion tank and directed through a flame arrester, sediment trap, gas meter and gas blower to a low pressure biogas storage tank. The storage tank acts as a buffer between daily gas production and daily use.

The biogas is used, without scrubbing, to fuel a 55 kW natural gas engine and drive a 40 kW electrical generator. This electrical power is used to displace purchased power to the farm.

The heat from the engine cooling system and from an exhaust gas heat exchanger is recovered and used to heat the farm house, and the digestion system. Radiant heat from the engine is used to heat the workshop.

The relatively odour free liquid remaining after anaerobic digestion flows by gravity to an earthen storage lagoon and is used as fertilizer on the farm land.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 275 m^3
Diameter: 7.3 m
Height: 7.3 m

Design Operating Temperature: 35 deg C

Design Hydraulic Retention Time: 9.5 days minimum

Design Loading Rate: 4.5 kg VS/m^3·d

Mixing System:

The mixing system consists of two submersible mixers mounted on a single mast. One mixer is located approximately 1 meter off the bottom of the digester and the other is located approximately 0.6 meter below the digester liquid surface level.

Mixing Energy Input: 4.5 kW (6 HP)

Digester Heating System:

The system consists of 100 meters of 5 cm diameter low carbon steel pipe in 5 loops in series - approximately 0.2, 0.4, 0.6, 0.8 and 1.0 meter off the bottom of the digestion tank and approximately 0.5 meter from the digester exterior wall.

Biogas Storage: Type of Storage: Steel tank
Location With Respect To Digester: Behind the workshop, near the engine generator set.
Capacity: 23 m^3
Pressure: 40 kPa

Size of Gas Blower: 735 m^3/d maximum capacity

Safety Equipment Used: Flame arrester, sediment moisture trap, biogas flow meter and a rotary lobe biogas blower.

D) BIOGAS UTILIZATION

Biogas Use: To Fuel an Engine Generator Set

Generator Size: 40 kW

Generator Type: Induction 220 V - single phase

Manufacturer: Leroy-Somer

Engine Size: 55 kW

Engine Type: 6 cylinder internal combustion engine

Manufacturer: Waukesha (Dresser)

Other Fuels Engine Operates With: Propane

Electrical Power Generation: 250 kW-hr/d

Use of Electrical Power: Displace purchased power to the farm.

Heat Recovery System:

The engine heat recovery system consists of two complete and separate cooling water circuits.

The primary engine cooling circuit consists of a water-to-water shell and tube heat exchanger, a coolant expansion tank, a recirculation pump and the digester heating coils.

The coolant in this circuit is pumped through the engine heat exchanger where it gains heat from the engine. The coolant flows to the coolant expansion tank to release any entrapped air and/or to expand as the coolant heats up. The suction side of the recirculation pump is connected to the bottom outlet of the expansion tank and the coolant is pumped through the digester heating coils and then returns to the engine heat exchanger. The flowrate through this loop regulates the temperature between 45 deg C and 55 deg C.

The engine operating temperature is regulated at 85 deg C by a thermostat located in the engine block.

A second heating loop consists of the engine recirculation pump, an exhaust manifold heat exchanger, an exhaust gas to water heat exchanger, a 27 m^3 hot water storage tank and a waste heat radiator.

A temperature sensor turns on the waste heat radiator fan if the cool water return temperature exceeds 75 deg C.

The hot water storage tank is connected to the hot water heating system in the house and to a hot water radiator in the grain dryer. Hot water from this tank is circulated as required through the house and grain dryer.

E) CAPITAL COSTS

SITE PREPARATION	$ 1,400.00 CDN
WASTE FEED SYSTEM:	
Manure feed pumps	6,743.00
Manure transfer line	5,305.00
DIGESTION TANK SYSTEM:	
Digestion tank	35,031.00
Heat exchange coils	3,612.00
Mixing system	12,522.00
Insulation	7,453.00
Gas and hot water piping	7,921.00
BIOGAS STORAGE AND UTILIZATION SYSTEM:	
Biogas storage	4,212.00
Biogas blower	2,903.00
Engine generator and biogas fuel train	38,910.00
Heat recovery system	4,117.00
MECHANICAL INSTALLATION	3,181.00
ELECTRICAL INSTALLATION	16,160.00
ENGINEERING DESIGN	16,500.00
TOTAL CAPITAL COST	$ 165,970.00 CDN

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

The engine generator size was selected on the biogas production rates calculated from volatile solids and volumetric manure production statistics in the literature and from laboratory studies on swine manure. Reduced volatile solids loading observed during the monitoring program, resulted in less than 40 % of the predicted biogas production. The generation system was designed to operate continuously and generate an average of 25 kW-hr. Since internal combustion engines require approximately 40% of the full fuel consumption to operate at the design engine speed with no load, the engine consumed all the fuel contained in the biogas storage tank in approximately 15 to 30 minutes and then shut down. The anaerobic digester required 15 to 30 minutes to produce enough gas to refill the storage tank after each shutdown. Modifications to the system are currently underway to correct this problem.

PHOTOGRAPH 8. LINDEN LEE FARMS ANAEROBIC DIGESTION FACILITY

4.10 McCain Foods Ltd.

A) GENERAL INFORMATION

Name: McCain Foods Ltd.

Address: Florenceville
New Brunswick
E0J 1K0
CANADA

Telephone Number: (506) 392-5541

Contact Person: J.H. Evans

Start-Up Date: Expected May 1986, currently under construction

Type of Operation: Food processing plant

Objectives of Digester: To treat potato processing waste

B) DIGESTER CHARACTERISTICS

Type: Anaerobic contact process with effluent clarification

Design Operating Temperature: 21 deg C

Design Flow Rate: 8,000 m3/d

Design BOD Loading Rate: 25,000 kg/d

Design Total Suspended Solids Loading Rate: 25,000 kg/d

Design Hydraulic Retention Time: 14 days

C) CAPITAL COSTS

Not Available

D) OPERATION AND MAINTENANCE COSTS

Not available

E) ESTIMATED SAVING

Not available

4.11 Millbank Cheese and Butter Ltd.

A) GENERAL INFORMATION

Name: Millbank Cheese and Butter Ltd.

Address: P.O. Box 100
Millbank, Ontario
NOK 1LO
CANADA

Start-Up Date: August 1984

Engineering Design : Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5M5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: Cheese Plant

Type of Waste: Cheese Whey

Wastewater Handling System:

Prior to the installation of the digester, the cheese whey was cooled and placed in a holding tank and hauled daily to a whey drying plant approximately 40 miles away. Presently, the whey is pumped to the holding tank and then to the anaerobic digester.

Objectives of Digester:

1. Provide an effective method to dispose of cheese whey.
2. Generate biogas for use in the boiler and to reduce fuel costs.
3. Reduce whey hauling requirements.
4. Eliminate the whey cooling costs.
5. Provide an environmentally acceptable effluent for spray irrigation.

B) PROCESS DESCRIPTION

Whey from the existing whey storage tanks at the cheese plant is pumped periodically each day to the digestion tank using the existing whey discharge pump. The digested whey is displaced through an overflow structure at the digester to a digester effluent sump and from there is pumped with two submersible pumps to the existing cheese plant wastewater pump house for discharge to the wastewater disposal site (a 12 hectare land panel located approximately 0.4 kilometers from the cheese plant).

The biogas is withdrawn from the digestion tank and directed through a foam separator, sediment trap, gas meter and gas blower to a 45 cubic meter low pressure biogas storage tank. This storage tank acts as a buffer between the daily gas production and daily use.

The biogas is used, without scrubbing, to fuel a 782 kg/hr (50 HP) high pressure steam boiler. The steam generated is used for the heating of the digester and for steam requirements within the cheese plant.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 1100 m^3
Diameter: 11.0 m
Height: 12.2 m

Design Operating Temperature: 34-35 deg C

Design Hydraulic Retention Time: 22 days

Design Loading Rate: 2.95 kg COD/$m^3 \cdot d$

Digester Mixing System:

The mixing system consists of 3 submersible mixers mounted on a single mast and located 1.5, 4.9 and 10.1 meters off the floor of the digester.

Digester Heating System:

Steam produced by the dual fueled boiler (biogas and #2 fuel oil) is injected directly into the digester to maintain the process temperature of 35 deg C.

Biogas Storage: Type: Low pressure metal tank
Location With Respect to Digester: Approximately 6 m away from the digester.
Capacity: 45 m^3
Pressure: Less than 55 kPa (less than 8 psig)

Size of Gas Blower: 4.2 m^3/min (150 cfm)

Safety Equipment Used: Flame arrester, pressure/vacuum relief valve, explosion proof equipment, air exchange fan.

D) BIOGAS UTILIZATION

Biogas Use: To fuel a boiler

Boiler Size and Type: 782 kg/hr (50 HP high pressure steam boiler)

Manufacturer: York-Shipley

Other Fuels the Boiler Operates With: Fuel Oil

Boiler Uses: 1. Heat the digester.
2. Provide steam to the cheese plant.

E) CAPITAL COSTS

SITE PREPARATION:

Soil tests	$ 2,200.00 CDN
Site grading and miscellaneous	3,361.50
Effluent storage	4,200.00

DIGESTION TANK SYSTEM:

Digestion tank c/w inserts, coating, insulation and metal cladding	102,194.23
Digester mixing	12,000.00

BIOGAS STORAGE AND UTILIZATION SYSTEM:	
Biogas handling and metering	22,426.72
Biogas storage	2,575.00
Dual fuel 782 kg/hr (50 HP) boiler	23,480.00
BUILDING CONSTRUCTION	15,018.66
MECHANICAL INSTALLATION	81,212.92
ELECTRICAL INSTALLATION	17,014.52
ENGINEERING DESIGN	36,993.53
TOTAL CAPITAL COST	$ 322,677.08 CDN

F) OPERATION AND MAINTENANCE COSTS (ESTIMATED)

SUPPLIES:	
Lubricants, minor piping adjustments ...	$ 1,000.00
REPAIRS:	
Estimated at 2% of capital cost	6,500.00
LABOUR:	
Operator 2 hr/d x 365 d/yr x $12/hr	8,700.00
Benefits (12% of labour cost)	1,100.00
CHEMICALS:	
500 L/d x 365 d/yr	83,950.00
ELECTRICITY (from monthly bills):	
$300 avg/month x 12 months/yr	3,600.00
TOTAL ESTIMATED OPERATION AND MAINTENANCE COST	$ 104,850.00/YR CDN

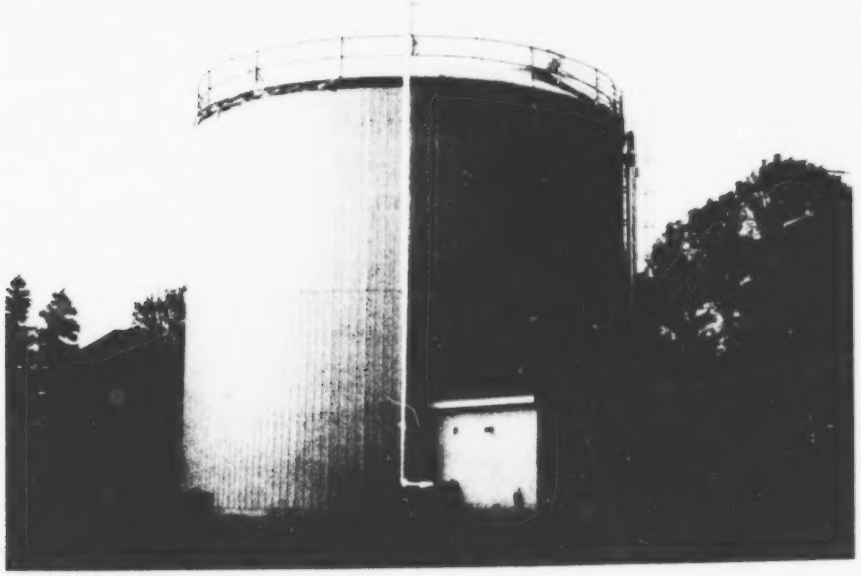
G) ESTIMATED SAVINGS

	Present Rate	Potential Rate*
Whey hauling	$ 127,750.00	$ 255,500.00
Biogas utilization	58,000.00	58,000.00
TOTAL ESTIMATED SAVING	$ 185,250.00/YR CDN	$ 313,500.00/YR CDN

*Whey hauling costs were predicted to double

H) SYSTEM PROBLEMS AND SOLUTIONS

Initial problems included maintaining the digester pH at greater than 7 and obtaining design loading rates. Initially, caustic soda (NaOH) was used to control the pH, but this proved costly and it was ineffective. Subsequently, effluent from a full-scale digester at a hog farm was obtained. At additions of 10 %, this has proven to be more effective.



PHOTOGRAPH 9. MILLBANK CHEESE AND BUTTER LTD. ANAEROBIC DIGESTION FACILITY

4.12 Olds College

No information currently available.

4.13 Pittens Farms Ltd.

A) GENERAL INFORMATION

Name: Pittens Farms Ltd.

Address: R.R. #6
Cambridge, Ontario
N1R 5S7
CANADA

Telephone Number: (519) 621-5769

Contact Person: John Pittens

Start Up Date: February 1986

Engineering Design: Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5M5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: Farm

Type of Waste: Dairy Cattle Manure

Number of Animals and Type: 200 Dairy Cows

Type of Housing: 110 m x 20 m Dairy Barn

Feed Composition: Corn silage and haylage

Type of Manure Handling System:

Manure falls through the slatted floors and is pumped to the digester.

Objectives of Digester:

1. Generate electricity.
2. Recover waste heat.

B) PROCESS DESCRIPTION

The manure from the barns is pumped periodically to a manure holding tank. From this holding tank the manure is pumped to the digestion system.

The biogas produced is withdrawn from the tank and directed through a gas blower to a low pressure 37.9 kPa (5.5 psig) gas storage tank. The biogas is used to fuel an internal combustion engine and to generate electricity to be used on the farm. The heat from the cooling water jacket of the engine and the exhaust gas is recovered and used to maintain the digester temperature, and to heat the milking parlor, the farm house and the farm workshop.

The relatively odour free digester effluent is stored in an earthen lagoon and utilized as fertilizer on cropland.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 275 m^3
Diameter: 7.3 m
Height: 6.6 m

Design Operating Temperature: 35 deg C

Design Hydraulic Retention Time: 15 days

Design Loading Rate: 4.7 kg VS/m^3·d

Digester Mixing System: The mixing system consists of 2 submersible mixers that operate continuously.

Biogas Storage: Type: Tar coated steel tank
Location With Respect To Digester: Buried next to the digester control building.
Capacity: 22.8 m^3
Pressure: 37.9 kPa (5.5 psig)

Size of Gas Blower: 0.7 m^3/min (25 scfm)

Safety Equipment Used: Moisture trap, sediment trap, flame arrester, outside vent to vent off excess gas.

D) BIOGAS UTILIZATION

Biogas Use: To Fuel an Engine Generator Set

Generator Size: 40 kW

Generator Type: induction generator

Manufacturer: Leroy Somer

Engine Size: 71 kW (95 HP)

Engine Type: 4 cylinder engine

Other Fuels Engine Operates With: Propane

Uses of Electrical Power Generated: On farm use

Heat Recovery System:

The engine heat recovery system consists of two complete and separate cooling water circuits. The primary engine cooling circuit consists of a water-to-water shell and tube heat exchanger, a coolant expansion tank, and the engine water pump and connecting pipes. The coolant (50/50 mix of water and antifreeze) in this circuit is pumped through the engine block, where it gains heat, it then flows through the engine side (hot) of the water-to-water heat exchanger, transferring the heat to the heating circuit side (cool) of the heat exchanger. The coolant flows to the coolant expansion tank to release any entrapped air and/or to expand as the coolant heats up. The suction side of the engine coolant pump is connected to the bottom outlet of the expansion tank and the coolant is continuously pumped through the circuit.

The engine operating temperature is regulated at 85 deg C by a thermostat located in the engine block.

A set of solenoid valves allow the engine coolant to be redirected to a waste heat radiator located outside the digester control building. These radiators are used when the heat from the engine block is not required.

The heating water loop (cool) consists of the shell and tube heat exchanger, the exhaust-to-water heat exchanger, a water expansion tank, a heating water recirculation pump, the digestion tank heating coils, a hot water radiator in the furnace plenum of the farm house, a hot water radiator in the farm shop, and the inter-connecting pipe.

The heating water circuit gains heat from the coolant side (hot) of the water-to-water heat exchanger then flows to the water side of the exhaust gas-to-water heat exchanger and gains heat from the engine exhaust gas. From the exhaust gas heat exchanger, the water flows to the digester heating coils. A set of manually operated valves are used to direct the hot water from the digester heating coils through the farm house and farm shop heating radiators, during the winter months.

The existing heating unit in the house was connected with a manual on/off switch. If the hot water heating circuit is unable to supply the heating demand for the house, the conventional heating unit can be turned on to provide supplemental heating.

E) CAPITAL COSTS

Waste feed system	$ 8,400.00
Digestion tank system	45,000.00
Biogas storage and utilization system	45,000.00
Building construction	8,000.00
Mechanical and electrical installation	34,200.00
Engineering design	22,000.00
Total Capital Cost (Estimated)	$ 162,600.00

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

Not available

PHOTOGRAPH 10. PITTENS FARMS LTD. ANAEROBIC DIGESTION FACILITY

4.14 Selves Farms Ltd.

A) GENERAL INFORMATION

Name: Selves Farms Ltd.

Address: R.R. #2
Fullarton, Ontario
NOK 1HO
CANADA

Telephone Number: (519) 229-8298

Contact Person: Laurie Selves

Start-Up Date: January 1983

Engineering Design: Canviro Consultants Ltd.

Address: 178 Louisa St.
Kitchener, Ontario
N2H 5W5
CANADA

Telephone Number: (519) 579-3500

Contact Person: Ray Stickney

Type of Operation: Farm

Type of Waste: Swine Manure

Number and Type of Animals: 400 sows farrow to finish

Type of Housing: Naturally ventilated finishing barn, conventional sow and starter barns

Feed Composition: Corn/soybean ration

Type of Manure Handling System:

Partially slatted floor, shallow manure pit barn. Manure is allowed to fill the pit 0.2 to 0.3 m deep before flowing by gravity to a central holding pit. Contents of holding pit are mixed with a submersible mixer prior to and during digester feeding.

Objectives of Digester:

1. Pollution control
2. Electrical generation
3. Recover waste heat
4. Recover single cell protein

B) PROCESS DESCRIPTION

Manure from the 400 sow farrow-to-finish unit is pumped twice daily to the digestion tank using the manure transfer pump. The digested liquid is withdrawn continuously for 8 to 16 hours each day.

The biogas is withdrawn from the digestion tank and directed through a foam separator, flame arrester, sediment trap, gas meter and gas blower to two 23 cubic meter low pressure biogas storage tanks buried beside the digestion tank. The storage tanks act as a buffer between daily gas production and daily use.

The biogas is used, without scrubbing, to fuel a 100 kW natural gas engine and drive a 90 kW electrical generator. This power is used to supply power to the home farm.

The cooling water from the engine cooling system and from an exhaust gas heat exchanger is recovered and used to heat the farm house, a mobile home located nearby, and the digestion system. Radiant heat from the engine is used to heat the workshop and feed mixing room in the finishing barn.

C) DIGESTER CHARACTERISTICS

Type: Completely Mixed Mesophilic

Size: Active Volume: 225 m^3
Diameter: 7.3 m
Height: 6.2 m

Design Operating Temperature: 35 deg C

Design Loading Rate: 6.5 kg VS/m^3·d

Digester Mixing System:

Digester contents are continuously mixed with 2 submersible style low energy mixers, one located about 1 meter from the bottom of the digester and the other located about 0.6 meter from the liquid surface level.

Digester Heating System:

The system consists of approximately 68 meters of 5 cm diameter low carbon steel pipe arranged in 3 loops in series, approximately 0.3, 0.6 and 1 meter off the bottom of the digestion tank floor and approximately 0.5 meter from the digester exterior wall.

Biogas Storage: Type: 2 buried metal storage tanks

Location With Respect To Digester: Next to digester control building.

Capacity: 45 m^3

Pressure: 40 kPa

Size of Gas Blower: 0.7 m^3/min (25 cfm)

Safety Equipment Used: Flame arrester, sediment trap, moisture trap, vent

D) BIOGAS UTILIZATION

Biogas Use: Engine Generator

Engine Size and Type: 6 cylinder natural gas fueled internal combustion engine.

Manufacturer: Caterpillar

Other Fuels Engine Operates With: Natural gas, liquid propane

Generator Size and Type: 90 kW asynchronous 220 V - 3 phase

Manufacturer: Stamford

Electrical Power Generated: 770 kW-hr/day

Uses of Electrical Power: Power for home farm

Heat Recovery System:

The engine heat recovery system consists of two complete and separate cooling water circuits.

The primary engine cooling circuit consists of a water-to-water plate and frame heat exchanger, a coolant expansion tank, two waste heat radiators, and the engine water pump and connecting pipes. The coolant (50/50 mix of water and anti-freeze) in this circuit is pumped through the engine block where it gains heat from the engine, it then flows through the engine side (hot) of

the water-to-water heat exchanger transferring the heat to the heating circuit side (cool) of the heat exchanger. The coolant flows to the coolant expansion tank to release any entrapped air and/or to expand as the coolant heats up. The suction side of the engine coolant pump is connected to the bottom outlet of the expansion tank and the coolant is pumped continuously through the circuit.

The engine operating temperature is regulated at 85 deg C by a thermostat located in the engine block.

A set of manual valves allow the engine coolant to be redirected from the water-to-water heat exchanger to two waste heat radiators located outside the digester control building. These radiators are used when the heat from the engine block is not required.

The heating water loop (cool) consists of a water-to-water plate and frame heat exchanger, an exhaust gas-to-water heat exchanger, a water expansion tank, a heating water recirculation pump, the digestion tank heating coils, a hot water radiator in the furnace plenum of a mobile home trailer, a hot water radiator in the furnace plenum of the farm house, and the inter-connecting pipe.

The heating water circuit gains heat from the coolant side (hot) of the water-to-water heat exchanger and then flows to the water side of the exnaust gas-to-water heat exchanger and gains heat from the engine exhaust gas. From the exhaust gas heat exchanger, the water flows to the heating water expansion tank where any entrapped air bubbles are removed and the water expands as it heats up.

The suction side of the heating water recirculating pump is connected to the bottom outlet of the heating water expansion tank. The heating water is pumped through the digestion tank heating coils and the radiators located in the mobile home trailer and the farm house respectively. Each of the radiators and the digester heating coils can be manually bypassed if heat is not required in the houses or the digestion tank.

The installation of the hot water radiators in the houses were integrated with the existing heating systems. The specially designed radiators were placed in the plenum of the existing forced air heating units (heat pump and electric furnace). Heating water from the heat recovery system is continuously circulated through the radiators and the fans on the existing forced air heating systems are connected directly to the thermostat in each house. When the thermostat calls for heat, the fan comes on, and heat is gained by the air passing over the hot water radiators. The existing heating units were connected with a manual on/off switch. If the hot water heating circuit is unable to supply the heating demand for the house, the conventional heating units can be turned on to provide supplemental heating.

E) SINGLE CELL PROTEIN RECOVERY SYSTEM

Recovery Method:

The protein recovery system is divided into two phases. The first phase of the system consists of a digester effluent withdrawal progressing cavity pump, a 0.6 meter diameter vibrating screen separator, a fibrous fraction solids auger, a screened solids manure spreader, and a 0.3 cubic meter vibrating screen effluent sump outfitted with high and low level floats to start and stop the digester effluent withdrawl pump. A third float mounted below the low level float shuts down the protein recovery system in the event that the pumps run dry.

The effluent from the first phase of the protein recovery system is pumped from the digester control building to the second phase of the protein recovery unit, located in the feed blending area of the barn.

The second phase of the system consists of a high speed (5100 rpm) solid bowl decanter type centrifuge, a 5 cubic meter conical bottom single cell protein storage bin, a progressing cavity single cell protein pump, a 1.4 cubic meter flocculant make up tank, flocculant metering system and a centrifugal final centrate (effluent) pump. The final effluent is pumped to the final effluent sump located in the digester control building and then to the two 600 cubic meter manure storage tanks.

Centrifuge Type: Solid bowl scroll

Manufacturer: Sharples

G Force: 2900 x G

Bowl Speed: High (5100 rpm)

Bowl Diameter: 15.2 cm

Bowl Length: 33.0 cm

Polymer: Type: Praestol 411K
Dosage: 2.5 kg/tonne
Feedrate: 18-20 L/min

F) CAPITAL COSTS

SITE PREPARATION:

Digging and grading	$ 1,413.25 CDN
Manure pumping and modification	31,625.25

DIGESTION TANK SYSTEM:

Digestion tank c/w fittings, manholes and insulation	26,807.36
Excavation and backfilling	3,832.50

BIOGAS STORAGE AND UTILIZATION SYSTEM:

Biogas handling and metering	1,491.66
Biogas storage	4,631.38
Electrical generation	36,562.97
Heat recovery and utilization	19,194.53

PROTEIN RECOVERY SYSTEM:

Primary separator	4,521.32
Polymer make-up and pumping	7,097.35
Centrifuge	64,815.40
SCP storage bin	2,835.00

BUILDING CONSTRUCTION:	
Digester control building	10,919.26
MECHANICAL INSTALLATION	21,716.20
ELECTRICAL INSTALLATION	18,949.82
ENGINEERING DESIGN	12,000.00
FREIGHT	829.43
TOTAL CAPITAL COST	$ 269,242.68 CDN

G) OPERATION AND MAINTENANCE COSTS

SUPPLIES	
Grease and oil	$ 450.00 CDN
Spark plugs, tune ups, etc.	200.00
Coolant losses	50.00
Miscellaneous	200.00
REPAIRS	
Engine generator set (2% of capital)	1,100.00
Protein recovery system (1% of capital)	800.00
Other repairs	1,000.00
LABOUR	
Operator 1 hr/d x 365 d/yr x $8/hr	2,920.00
Benefits (12% of labour cost)	350.00
CHEMICALS	
Polymer (1 kg/d)	1,750.00
TOTAL OPERATION AND MAINTENANCE COSTS	$ 8,820.00/YR CDN

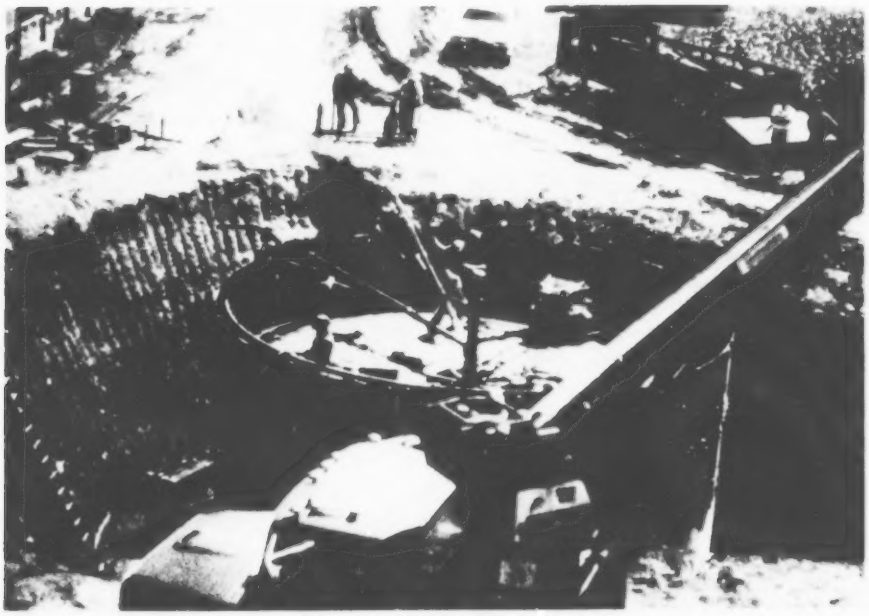
H) ESTIMATED SAVINGS

Electrical generation (102,500 kW·hr/yr @ $0.04/kW-hr)	$ 4,100.00 CDN
Heating costs	2,000.00
Protein recovery (12.5 % soybean replacement)	34,800.00
TOTAL ESTIMATED SAVING	$ 40,900.00/YR CDN

I) SYSTEM PROBLEMS AND SOLUTIONS

The failure of safety relief equipment caused over pressure in the digestion tank and cracked the concrete. An expanding resin was used to repair the damage.

The exhaust gas heat exchanger on the engine exhaust failed in less than 6 months from corrosion caused by condensation. A new style of exhaust gas heat exchanger was designed and installed.



PHOTOGRAPH 11. SELVES FARMS LTD. ANAEROBIC DIGESTION FACILITY

4.15 University of Guelph

Two of the anaerobic digestion facilities at the University of Guelph Arkell Research Station have been included.

4.15.1 16 m^3 Intermittent Mix Research Digester

A) GENERAL INFORMATION

Name: University of Guelph, Arkell Research Station

Address: School of Engineering
University of Guelph
Guelph, Ontario
N1G 2W1
CANADA

Telephone Number: (519) 824-4120

Contact Person: Vladimir Pavlicik

Start-Up Date: 1982

Engineering Design: School of Engineering
University of Guelph

Type Of Operation: University research station, swine operation

Type of Waste: Swine Manure

Number and Type of Animals: 200 growing and finishing pigs

Type of Housing: Conventional enclosed barn with several research units at the end of the barn.

Feed Composition: Corn/barley, soybean ration

Type of Manure Handling System:

The digester influent is premixed in the collection pit of the barn with the aid of a back flushing system. The manure is allowed to stratify, and then the supernatant and solids below the scum layer are pumped to a premixing tank where the influent is sampled and the volume is measured before being pumped into the digester.

Objectives of Digester: Research facility

B) PROCESS DESCRIPTION

Manure from the 200 growing and finishing pig barn is pumped to a premixing tank where it is heated.

The digester consists of a 16 m^3 vertical cylindrical fibreglass reinforced plastic tank set on a concrete hopper base. The unit is covered with a sprayed-on polyurethane insulation.

The biogas is withdrawn from the digestion tank and can be transferred to storage, burned in the boiler, used to fuel an engine/generator set or vented to the atmosphere.

Effluent flows from the digester to a holding tank.

C) DIGESTER CHARACTERISTICS

Type: Conventional Intermittent Mix Research Digester

Size: Active Volume: 9.76 m^3 (16 m^3 total)

Design Operating Temperature: 35 deg C

Loading Rate: Varies according to research being conducted

Design Hydraulic Retention Time: 14 days

Digester Mixing System:

Digester contents are mixed intermittently with a GSW Barns 2.6 kW (3.5 HP), 3 phase submersible recirculation pump. Three balanced 5 cm jets are installed in the outlet of the pump. One jet is directed at the outlet of the hopper base to prevent plugging and to keep solids in suspension, another is aimed tangentially at mid-depth to swirl the digester contents and the third is directed towards a scum breaking lattice assembly, which in combination with the swirling action keeps the scum broken up and mixed in.

Digester Heating System:

Two boilers are used to maintain the temperature of the digester contents. One boiler operates with propane and is used during start-up periods. The other has been modified to burn biogas for use during normal operation. A heating grid, constructed of 3.8 cm (1.5 inch) black iron pipe is installed in the bottom of the digester. Thermostatically controlled valves control the flow of the hot water from the boilers through the heating grid.

Biogas Storage: Type: Butyl rubber bag

Location With Respect To Digester: Adjacent to the digester control building

Capacity: 90 m^3

Pressure: 1.5 kPa (6 inches water)

Safety Equipment Used:

High pressure gas piping and pressure release venting, explosion proof wiring and fixtures in areas in direct contact with the digester and outdoor gas storage, proper ventilation, gas sensors, alarm and fire extinguishers.

D) BIOGAS UTILIZATION

Biogas Use: Depends on research activity. Biogas has been used to fuel a boiler,an engine/generator set,a catalytic heater,a lantern and attempts were made to fuel a propane stove and a refrigerator.

E) CAPITAL COSTS

Not available

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

Problems, such as plugging of lengths of pipe and air leakage into the recirculation pump, were encountered with the original digester mixing system (external mixing system). Digester contents are now mixed with three submersible recirculation pumps.

4.15.2 45 m^3 Underground Farm Scale Demonstration Digester

A) GENERAL INFORMATION

Name: University of Guelph, Arkell Research Station

Address: School of Engineering
University of Guelph
Guelph, Ontario
N1G 2W1
CANADA

Telephone Number: (519) 824-4120

Contact Person: Vladimir Pavlicik

Start-Up Date: 1982

Engineering Design: School of Engineering
University of Guelph

Type Of Operation: University research station, swine operation

Type of Waste: Swine Manure

Number and Type of Animals: 250 growing and finishing pigs

Type of Housing: Conventional enclosed barn

Feed Composition: Corn/barley, soybean ration

Type of Manure Handling System:

Manure collected from the barn is passed via a pump house to an above ground premixing tank housed in the control building above the submerged digester. After sampling, the influent is gravity fed into the main digester tank.

Objectives of Digester: Research facility

B) PROCESS DESCRIPTION

Manure from the 250 growing and finishing pig barn is pumped to a premixing tank where it is heated.

The digestion system consists of two 45 m^3 precast concrete septic tanks. One tank is used as the digester and the other as an effluent storage tank and secondary digester. The two tanks can also be operated as parallel digesters, doubling the throughput capacity of the facility.

The biogas is withdrawn from the digestion tank and can be transferred to storage, burned in the boiler or vented to the atmosphere.

Effluent flows from the digester to a holding tank.

C) DIGESTER CHARACTERISTICS

Type: Underground Farm Scale Demonstration Digester

Size: Active Volume: Two 37.7 m^3 (45 m^3 total) septic tanks made of 2 precast concrete

Design Operating Temperature: 35 deg C

Design Loading Rate: 1.5 kg $VS/m^3 \cdot d$

Design Hydraulic Retention Time: 30 days

Digester Mixing System:

Mixing is accomplished by recirculating the digester contents. Slurry is drawn from the bottom of the digester through a 10 cm gravity drain line and pumped by means of a 3.7 kW (5 HP) multipurpose sewage pump through a 7.5 cm pressure line back into the bottom of the tank. Mixing is carried out for 30 minutes twice daily.

Digester Heating System:

Two 19 kW (65,000 BTU/hr) boilers are used to preheat the digester influent and to provide heat for the utility building. One boiler operates on propane and is used during start-up periods. The other has been modified to burn biogas for use during normal operation. A heat exchanger constructed of 3.8 cm (1.5 inch) black iron pipe was placed in the bottom of the influent tank. Thermostatically controlled solenoid valves control the flow of heating water through the heat exchanger and the passive fin radiators installed for building heat.

Biogas Storage: Type: Butyl rubber bag

Location With Respect To Digester: adjacent to the digester control building

Capacity: 90 m^3

Pressure: 1.5 kPa (6 inches water)

Safety Equipment Used:

High pressure gas piping and pressure release venting, explosion proof wiring and fixtures in areas in direct contact with the digester and outdoor gas storage, proper ventilation, gas sensors, alarm and fire extinguishers.

D) BIOGAS UTILIZATION

Biogas Use: To Fuel a Boiler

Boiler Size and Type: 19 kW (65,000 BTU/hr)

Manufacturer: Hydrotherm

Other Fuels Boiler Operates With: Propane

Boiler Uses: To provide hot water to maintain digester contents at process operating temperature of 35 deg C and to provide heat for the control building.

E) CAPITAL COSTS

Not available

F) OPERATION AND MAINTENANCE COSTS

Not available

G) ESTIMATED SAVINGS

Not available

H) SYSTEM PROBLEMS AND SOLUTIONS

The major problem was obtaining a gas tight seal for the two 45 m^3 tanks. The major source of leakage was thought to be at the joint between the upper and lower halves of the tank. The inside of the joint was epoxyed and a layer of pentite sealant was sprayed on the interior surface. Further testing indicated that the leakage was still unacceptable. It was determined that the main problem was in the weir connection between the two tanks since leakage was still substantial when testing was carried out with the water level above the points. After several unsuccessful attempts to correct the problem, the rigid connection between the two tanks was replaced with a flexible connection. This required some modification of the gas handling system because the 2 gas tanks no longer shared a common gas space.

PHOTOGRAPH 12. UNIVERSITY OF GUELPH, ARKELL RESEARCH STATION ANAEROBIC DIGESTION FACILITIES

5.0 CONCLUSIONS

The anaerobic digestion process has been applied effectively to a variety of agricultural and industrial wastes in Canada. Engineering design and current operational data from Canadian anaerobic digestion facilities is now available in a standard format on the CoSy Computer Conferencing System at the University of Guelph, Guelph, Ontario. The data base and conferencing system are accessible across Canada through DATAPAC, TYMNET and TELENET to government personnel, engineering firms, industries and individuals attempting to design or evaluate the technology.

The long term monitoring and data collection program was developed and the implementation of the program started in January 1986. The information collected will be used to update the data base.

Posters on representative Canadian anaerobic digestion facilities and the data base concept were prepared and presented at the Fourth International Symposium of Anaerobic Digestion held in Guangzhou, China in November 1985.

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APPENDIX A

QUESTIONNAIRE FOR THE LONG TERM MONITORING AND DATABASE DEVELOPMENT PROJECT

QUESTIONNAIRE FOR THE LONG TERM MONITORING AND DATA BASE DEVELOPMENT PROJECT

A) GENERAL INFORMATION

Name _____
Address _____
_____
_____
Telephone Number _____
Contact Person(s) _____
Start-Up _____

Engineering Design Work _____
Address _____
_____
_____
Telephone Number _____
Contact Person(s) _____

Type of Operation ☐ Farm ☐ Industry

If Farm: No. of Animals _____
Type of Animals _____
Type of Housing _____
Feed Composition _____
_____
_____
_____

Feeding Routine _____
_____
_____
_____

Type of Manure Handling System (prior to entering digester) __
_____
_____
_____
_____

Objectives of Digester _____
_____
_____
_____
_____
_____
_____
_____

If Industry: Type of Operation _____

Wastewater Handling System _____

_____

_____

_____

_____

Objectives of Digester _____

_____

_____

_____

_____

B) PROCESS DESCRIPTION (include schematic of the system)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

C) WASTE CHARACTERISTICS

Type of Waste _____

Waste Volume Pumped (m^3/d) _____

Waste Dry Matter Concentration (%) _____

Production Schedule (hrs/d) _____

TS	_____	pH	_____
VS	_____	TKN	_____
SS	_____	NH_3-N	_____
COD	_____	P	_____
BOD	_____	K	_____

D) DIGESTER CHARACTERISTICS

Type _____

Size Active Volume (m^3) _____

Diameter (m) _____

Height (m) _____

Design Operating Temperature (°C) _____
Design Hydraulic Retention Time (d) _____
Design Loading Rate (kg VS/m^3/d) _____
Design Loading Rate (kg COD/m^3/d) _____
Digester Mixing System (brief description) _____
_____
_____
Digester Mixing Energy Input (hp or kW) _____
_____
_____
Digester Heating System (brief description) _____
_____
_____
Recirculation Rates (if any) _____
Heat Demand Manure Waste Heating (GJ/d) _____
Digester Shell Losses (GJ/d) _____

E) EFFLUENT CHARACTERISTICS

Flowrate (m^3/d) _____
Method of Storage _____
Storage Volume _____
Storage Capacity (no. of days) _____
Method of Disposal _____
_____
_____

TS	_____	% Removal	_____
VS	_____	% Removal	_____
SS	_____	% Removal	_____
BOD	_____	% Removal	_____
COD	_____	% Removal	_____
pH	_____		

Fertilizer Value	TKN _____	P	_____
	NH_3-N _____	K	_____
	Ca _____	Na	_____

F) BIOGAS CHARACTERISTICS

Biogas Production (m^3/m^3/d) _____
Specific Biogas Production (m^3/kg VS added) _____
Biogas Quality (methane content) _____

Biogas Storage: Type of Storage _____

_____

Location with respect to Digester _____

_____

Capacity (m^3) _____

Pressure (kPa) _____

Size of Gas Blower _____

Safety Equipment Used _____

_____

G) BIOGAS UTILIZATION

Biogas Use ☐ Boiler ☐ Engine Generator ☐ Other

If Boiler:

Boiler Size _____

Boiler Type _____

Manufacturer _____

Other Fuels Boiler Operates with _____

_____

_____

Biogas Scrubbing _____

Method _____

_____

Boiler Use(s) _____

_____

_____

Manufacturer _____

If Engine Generator:

Generator Size _____

Generator Type _____

Manufacturer _____

Other Fuels Generator Operates with _____

Engine Size _____

Engine Type _____

Manufacturer _____

Other Fuels Engine Operates with _____

Electrical Power Generation (kW/d) _____

Biogas Scrubbing _____

Method _____

_____

Use(s) of Electrical Power _____

_____

_____

Heat Recovery System _____

_____

_____

_____

_____

If Other Describe: _____

_____

_____

H) SOLIDS RETENTION TIME CONTROL

Is SRT control being used ☐ Yes ☐ No

Method of Biomass Separation

a) Settling - No Assistance ☐

- Chemical Assistance ☐
  - What Chemical _____
- Mechanical Assistance ☐
  - Method _____

_____

b) Centrifugation

- Centrifuge Type _____
- Manufacturer _____
- G Force _____
- Bowl Speed _____
- Bowl Diameter _____
- Bowl Length _____
- Chemical Assistance ☐ Yes ☐ No
- What Type of Chemical _____

I) SINGLE CELL PROTEIN CHARACTERISTICS

Is SCP being recovered? ☐ Yes ☐ No

Recovery Method:

a) If centrifuge:
- Centrifuge Type _____
- Manufacturer _____
- G Force _____
- Bowl Speed _____
- Bowl Diameter _____
- Bowl Length _____
- Chemical Assistance ☐ Yes ☐ No
- What Type of Chemical _____
- Process Description _____

b) If other describe - _____

Quantity Recovered (kg wet cake/m^3 of digester effluent centrifuged)

_____

Crude Protein Content _____

TS _____

Refeeding
Quantity (% Replacement) _____
Method _____

Polymer
Type _____
Dosage _____
Feedrate _____

J) CAPITAL COSTS

Site Preparation

Waste Feed System

Digestion Tank System

Biogas Storage and Utilization System

Protein Recovery System

Building Construction

Mechanical Installation

Electrical Installation

Engineering Design

Other

Total Capital Cost

K) OPERATION AND MAINTENANCE COSTS

Supplies

Repairs

Labour

Chemicals

Electricity

Other

Total Operation and Maintenance Cost

L) ESTIMATED SAVINGS

Electrical Generation
Heating Costs
Protein Recovery
Others

Total Estimated Saving

M) DESIGN PROBLEMS

Brief Description

Solution

N) OPERATIONAL PROBLEMS (Are operating conditions same as design specifications?)

Solution

O) CURRENT OPERATIONAL STRATEGY (brief description of current operating conditions and any tests or research that is being performed)

P) OTHER INFORMATION

Are any on-site records being kept? If so, what type of records?

Are these records available for our use? ☐ Yes ☐ No

Would it be possible to collect samples in the future?

☐ Yes ☐ No

Would you be interested in accessing the data from other digestion systems on this data base?

☐ Yes ☐ No

Comments:

APPENDIX B

LOGGING ON TO THE CoSy COMPUTER CONFERENCING SYSTEM AND ACCESSING THE DATA BASE

LOGGING ON TO THE CoSy COMPUTER CONFERENCING SYSTEM AND ACCESSING THE DATA BASE

Logging on to the CoSy Computer Confering System

The following is the procedure to access the data base on the CoSy System through DATAPAC 3101 (see Appendix C for DATAPAC 3101 telephone numbers):

Procedure	Network/Operator Response
1. Set the speed of your terminal to 300 or 1200 baud.	Nil
2. Set your machine to half duplex, even parity, caps lock off (lower case) and ASCII mode.	Nil
3. Turn on the terminal.	Nil
4. Turn modem on and/or make sure the terminal is on-line.	
5. Dial the DATAPAC public dial access number for the city you are in (see Appendix B). At the sound of the tone, place the telephone receiver in the acoustic coupler.	
6. Enter (CR) to establish a connection to the network. [Whenever you see (CR), it means press the RETURN key].	(CR)
7. DATAPAC will identify itself and your network address and will wait for your call request...	DATAPAC: *terminal address *This address can be any 8-digit number.
8. Enter call request of 34200142 (CR). This command should connect you to the University of Guelph CoSy system.	34200142 (CR)

Procedure	Network/Operator Response
9. DATAPAC will respond with a connection message. You are not connected to the Gandalf network at the University of Guelph.	DATAPAC; call connected
10. A number of other lines will appear, ending with: ; NAME: CoSy is now requesting that you enter your CoSy name and password. Type the name you have been assigned, then press carriage return.	; Name: abrown Password? mxplt
Please note: When COSY requests; ; Name: and password, you must type these without backspaces or corrections. If you do make a mistake simply press return until you get the "Name:" prompt again and then start over. All other parts of COSY allow you to use the backspace key normally.	
11. All new participants in CoSy are registered in a conference called "learn". "Learn" is a tutorial which will familiarize you with the basic operations of CoSy. Simply press (CR) and you will be joined to the learn conference. Once you receive the message that you are joining learn you should press (CR) again to see the first message. Follow the instructions given in the learn conference and you will complete the introductory tutorial.	(CR)
12. You may wish to change your password. Type password, and follow the instructions given. Be sure you remember your ID and password for the next time you sign on.	; Password

Procedure	Network/Operator Response
13. Type "bye", then carriage return to terminate your session.	; Bye

DATAPAC 3101 telephone numbers are listed in Appendix C.

Note: More information can be obtained by consulting the CoSy Computer Conferencing System User's Guide Version 3.1+.

Autolog software can be used to log on to CoSy instead of using the manual procedure described above. An example autologging procedure using CROSSTALK XVI by Microstuf Inc. is shown in Appendix D.

Accessing the Data Base

The following is the procedure to join one of the six Canadian Anaerobic Digestion Data Base Conferences, while connected to CoSy.

1. While at the main level of CoSy (the prompt character at this level is ":") type :
   JOIN "Conference Name"
   "Conference Name" can be INTRO, DIGESTERDESIGN, etc....

2. Once a conference has been selected, a list of the Topics contained in the Conference will appear with the prompt **TOPIC?**

"Topic names" apply to the 15 anaerobic digestion sites. The "Topic names" for each site are summarized in Table 2.

Once a Topic has been selected, the number of Messages in the Topic will appear. Type "1" when the **READ:** prompt appears to see the first Message in the Topic.

A Conference or a Topic can be exited at any time by typing **QUIT** .

To terminate a session, type **BYE** .

Sample Conferencing Session:

```
; Name:
  Password?
```
abrown
mxplt

```
*** CoSy 111.1 ***
```

CONF/TOPIC	NEW MESSAGES
INTRO/.....	
DIGESTERDESIGN/.....	
OPCONDITIONS/.....	
MONTHREPORT/.....	
YEARREPORT/.....	
DISCUSS/.....	

```
:
```
join digesterdesign

```
List of Topics will be shown
Topic?
```
selves

```
Read:
```
1

```
Topic/Message
Contents will appear
```

```
Read:
```
quit (or <CR> to see next message or next active Topic)

```
:
```
join opconditions (or any other Conference) or
BYE (to terminate session)

Adding Comments to the Data Base

To improve the readability and increase the clarity of the information in the data base, all of the Conferences, except **DISCUSS**, are READ-ONLY. No comments can be added by the data base users to these Conferences.

The DISCUSS Conference is designed to be a discussion forum for information exchange. The Conference contains a Topic for each anaerobic digestion facility and a Topic called GENERAL for comments that do not apply to a particular site.

To reply to, or comment on, a particular message, use the **COMMENT** command. First, join the DISCUSS Conference and then select a topic (see Table 1). Position yourself just after the Message you wish to comment on or just after the Comment to which you wish to reply to.

The system will have displayed the read prompt as:

READ:

Now type:

comment

and press carriage return.

You are now ready to enter characters for your message. You are in "input mode" where everything that is typed will be accepted as text. Type as many lines as required to complete your message. Blank lines may be imbedded by hitting the carriage return when prompted for text. If there are mistakes, corrections may be made by using the backspace key to back up in the current line. A period (.) at the start of the line followed by carriage return will end "input mode".

CoSy will now ask what action to take with the text. If ? is typed, the following alternatives will be shown:

A(dd) add the text to the conference, and clear scratchpad
E(dit) enter the editor
C(lear) clear the text and return to entry point
L(ist) display the contents of your scratchpad
Q(uit) leave the text and return to entry point

The normal response (if you are satisfied with the text as you've entered it) is to type a (for add), to complete the process of adding your comment to the proper place in the DISCUSS conference.

APPENDIX C

DATAPAC 3101 PUBLIC DIAL PORTS

DATAPAC 3101 PUBLIC DIAL PORTS

	AREA CODE	300 BPS	1200 BPS
BRITISH COLUMBIA			
Kamloops	(604)	374-5941	
Kelowna	(604)	860-0331	860-9762
Nelson	(604)	354-4411	354-4824
Prince George	(604)	564-4060	562-8469
Terrace	(604)	635-7221	
Vancouver	(604)	689-8601	687-7144
Victoria	(604)	388-9300	386-0900
ALBERTA			
Calgary	(403)	264-9340	290-0213
Edmonton	(403)	420-0185	423-4463
Fort McMurray	(403)	791-2884	743-5207
Grande Prairie	(403)	539-0100	539-6434
Lethbridge	(403)	329-8755	327-2004
Medicine Hat	(403)	526-6587	529-5521
Red Deer	(403)	343-7200	342-2208
SASKATCHEWAN			
Moose Jaw	(306)	693-7611	
Prince Albert	(306)	922-4233	922-4234
Regina	(306)	565-0111	565-0181
Saskatoon	(306)	665-6660	665-7758
MANITOBA			
Brandon	(204)	725-0878	727-6609
Thompson	(204)	778-4461	778-4451
Winnipeg	(204)	475-2740	475-2710
ONTARIO			
Barrie	(705)	737-4100	737-4120
Belleville	(613)	966-6002	966-9301
Brampton	(416)	791-8900	791-8950
Brantford	(519)	756-0000	756-0020
Brockville	(613)	345-0520	345-3780
Chatham	(519)	354-7710	354-7716
Clarkson	(416)	823-6000	
Cornwall	(613)	938-9700	
Galt	(519)	622-1714	
Guelph	(519)	836-7930	
Hamilton	(416)	523-6800	523-6900
Kingston	(613)	549-7720	549-7760
Kitchener/Waterloo	(519)	579-0009	579-0310

	AREA CODE	300 BPS	1200 BPS
ONTARIO			
London	(519)	679-7500	679-7620
Niagara Falls	(416)	357-2702	357-2770
North Bay	(705)	476-3900	476-3920
Oshawa	(416)	579-8920	579-8950
Ottawa	(613)	567-9100	567-9300
Peterborough	(705)	748-6940	748-6945
St. Catharines	(416)	688-5620	688-5640
Sarnia	(519)	336-9920	336-0950
Sault St. Marie	(705)	942-4960	942-4970
Sudbury	(705)	673-9602	673-9652
Thunder Bay	(807)	623-9644	623-3270
Toronto	(416)	868-4000	868-4100
Windsor	(519)	973-1000	973-1020
Woodstock	(519)	485-5220	
QUEBEC			
Granby	(514)	375-1240	375-4184
Joliette	(514)	759-8340	759-8381
Jonquiere/Chicoutimi	(418)	545-2272	545-2290
Montreal	(514)	878-0450	878-0640
Quebec City	(418)	647-4690	647-2691
St. Hyacinthe	(514)	774-9270	
St. Jean	(514)	346-8779	347-6211
Sherbrooke	(819)	566-2770	566-2990
Trois Rivieres	(819)	373-2600	373-2603
Valleyfield	(514)	377-1260	377-1680
NEW BRUNSWICK			
Bathurst	(506)	546-4461	548-4581
Fredericton	(506)	454-9462	454-4525
Moncton	(506)	854-7078	854-7510
Saint John	(506)	693-7399	642-2231
NOVA SCOTIA			
Bridgewater	(902)	543-6850	543-1360
Amherst	(902)	667-5035	667-5297
Halifax	(902)	477-2000	477-8000
Kentville	(902)	678-1030	678-2096
New Glasgow	(902)	752-0944	752-1731
Sydney	(902)	539-7010	539-8040
Truro	(902)	662-3258	662-3773
PRINCE EDWARD ISLAND			
Charlottetown	(902)	569-3391	569-3784
NEWFOUNDLAND			
St. John's	(709)	726-4920	726-5501

APPENDIX D

LOGON PROCEDURE USING CROSSTALK XVI SOFTWARE ON AN IBM PC/XT OR AT AND A HAYES SMARTMODEM

LOGON PROCEDURE USING CROSSTALK XVI SOFTWARE ON AN IBM PC/XT OR AT AND HAYES SMARTMODEM

To logon to the CoSy Computer Conferencing System at the University of Guelph through DATAPAC 3101 using CROSSTALK XVI by Microstuf Inc. on an IBM PC/XT or AT, a command file and a script file must be created. **COSY.XTK**, the command file, sets the protocol and the function keys on the computer and provides CROSSTALK with the parameters to dial CoSy through DATAPAC 3101. **COSY.XTS**, the script file, tells CROSSTALK what to do once it has made the telephone connection.

The following is a listing of the **COSY.XTK** file:

File **COSY.XTK**

CONTENTS OF FILE		**COMMENTS**
NAme	CROSSTALK defaults (Hayes Smartmodem)	Title of File
NUmber	5790310	DATAPAC 3101 Telephone Number (different in each area; see Appendix B)
ACcept	Everything	Allows Caller Full Access to System
ANswback	Off	No Answerback
APrefix	ATSO=1	Tells Modem What Ring to Answer On
ATten	Esc	Set Our Normal Attention Key
BReak	End	and Our Normal Break Key
SWitch	Home	and Our Normal Switch Key
CWait	None	Don't Need CWAIT
LWait	Char '>'	Wait for > Character
DEbug	Off	No DEBUG
DPrefix	ATDP	Dial with Pulses
DSuffix		Sets Dialing String and Includes a CR
EMulate	None	Sets Type of Terminal to Emulate
EPath	A:/PE.EXE	Tells CROSSTALK Where to Find Text Editor
FIlter	--------++++-++----------	Used to Display and Change Allowable Control Characters
INfilter	On	Filter Junk Characters Out
LFauto	Off	Don't Need Extra Line Feeds
MOde	Call	We are Making a Call
POrt	1	Use Communications Port 1
PWord	""	Disables Password Feature

File **COSY.XTK** (continued)

CONTENTS OF FILE		**COMMENTS**
RDials	10	Sets Number of Attempts to Connect
TImer	On	Displays Online Connection Time on Screen
TUrnarnd	Enter	Send CR When We Press CR
BKsize	1	Sets Data Block to One 256 Byte Increment
DNames	200	Reserves Space for 200 Names
CApture	Off	No Data will be Captured
COmmand	ETX (C)	Sets Command Key to C
FLow	S/ Q	Normal XON XOFF Characters
PArity	None	Sets Parity Bit to Appropriate Value
DAta	8	8 Bit Data
DUplex	Half	Half Duplex
OUtfiltr	On	Filter Ongoing Line Feeds
PMode	2 (DOS)	Tells System the Type of System it is Communicating with
PRinter	Off	Start with Printer Off
SPeed	1200	1200 Baud
STop	1	1 Stop Bit
TAbex	Off	Tab Expansion Off
BLankex	Off	Will Disregard Blank Lines
UConly	Off	Lower Case is Acceptable
FK 1 ""		
FK 2 ""		
FK 3 ""		
FK 4 CROSSTALK - XVI		
FK 5 @CApture /:		F5 Toggles Capture On/Off
FK 6 @PRinter /:		F6 Toggles Printer On/Off
FK 7 @TYpe:		F7 will Review the Buffer
FK 8 @CApture <24:		F8 will Capture 24 Lines in the Memory
FK 9 @SNap:		F9 will Review Snapshot
FK 10 @SNap 24:		F10 will Take a Snapshot of 24 Lines on a Screen
GO q45/45		Re-dial Until We Connect

The following is a listing of the **COSY.XTS** file:

File **COSY.XTS**

CONTENTS OF FILE	**COMMENTS**
wait quiet 20	Wait Until Line is Quiet for 2 Seconds
reply¦	Reply 1200 Baud
wait quiet 10	Wait Until Line is Quiet for 1 Second
reply 34200142¦	Reply Call Request Number for the University of Guelph and CR
wait string "Name:"	Wait for CoSy to Ask You for Your ID Name
reply canviro¦	Reply Your ID Name and Cr
wait string "PASSWORD:"	Wait for CoSy to Ask You for Your Password
reply xyz	Reply Your Password and CR

The following is a typical CROSSTALK XVI Status Screen:

```
                    CROSSTALK - XVI Status Screen                Off Line

NAme    CROSSTALK defaults (Hayes Smartmodem)  LOaded   A:COSY.XTK
NUmber  5790310                                CApture  Off

      Communitcations parameters                    Filter settings
SPeed 1200   PArity None   DUplex   Half      DEbug     Off   LFauto   Off
DAta  8      STop   1      EMulate  None      TAbex     Off   BLankex  Off
POrt  1                    MOde     Call      INfilter  On    OUtfiltr On

           Key settings                          Send control settings
ATen    Esc                COmmand ETX ( C)   CWait     None
SWitch  Home               BReak   End        LWait     Char '>'

                        Available command files

1) COSY
```